LIVING PICTURES

HOPWOOD'S
LIVING PICTURES

THEIR HISTORY, PHOTO-PRODUCTION, AND PRACTICAL WORKING, WITH CLASSIFIED LISTS OF BRITISH PATENTS AND BIBLIOGRAPHY

BY

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BARRISTER-AT-LAW OF LINCOLN'S INN

NEW EDITION, REVISED AND ENLARGED

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PREFACE TO SECOND EDITION

A SECOND EDITION of my work has been contemplated for some time, but circumstances have prevented me from devoting the large number of hours necessary for the accurate verification of facts and the revision of the book. I can only express my gratification that the labour has been undertaken by a friend in whom I have the greatest confidence.

For the moment it is interesting to look back to the days in which the First Edition appeared. That year marked the transition from history to actuality; it was the period of search for new types of machines, for new methods, and attempted forecasts of the future. Yet I think it very doubtful whether many of those most interested at that date foresaw the actual commercial development which has taken place. Putting technical matters aside for the moment, we may safely say that in 1899 the Living Picture was a popular music-hall "turn." To-day it has established its own theatre, its own personnel, its own audience. Technical advance has been great. The more effective types of machines have been perfected; the actors of the day act for the screen, just as they do for the auditorium; a whole network of recording energy is spread over the entire world. In this year of grace the Living Picture is possessed of an organization so complete, so far-spread, that its future existence and expansion is assured. It has entered into the life of

the peoples; it has become a permanent part of their recreation and education.

And yet, wonderful as has been the progress of the past twelve years, more wonderful still will be the coming decade. To-day we again stand looking to the future, as we did in ninety-nine. Then we hoped for the perfecting of the monochrome picture, and that has come. But to-day shows us the promise of reality itself. Colour projection has made great strides, soon we may see its perfection. Sound and sight have in the past been linked by artifice, but now we are in touch with the actuality of simultaneous recording of sound and picture—a veritable record of events as entirely perfect as human sensation can demand. In a few years time will no longer exist; any event, the gorgeous pageant, the historic speech, the actor with his every intimate gesture and familiar intonation, will live for ever. The history of the past few years shows us how this may be, and it is such a history that this edition records. A perusal of the proofs assures me that the facts are well presented, and the cordial relations which have existed between the reviser and myself entirely remove my natural regret that the whole work is not my own.

HENRY V. HOPWOOD.

LONDON, 1912.

REVISER'S PREFACE

One or two remarks will suffice to explain what has been attempted in revising this work. The original text of the old edition has, where possible, been left unaltered. Chapters I., II., and III., dealing with the historic evolution of the Cinematograph, have been but slightly altered. Chapters IV. and V., dealing with present-day apparatus and films, have of necessity been largely rewritten. In Chapter VI. only the chief points in manipulation and practice have been dealt with. To have done full justice to this part of the subject would have necessitated much more space than is available. Chapter VII., dealing with Pictures in Colours, Chapter VIII., dealing with Speaking Pictures, and Chapters IX. and X., dealing with Legal Matters, are entirely new. In dealing with present-day applications and with film-subjects in Chapter XI., a large portion of the original text has been rewritten. In Appendix I. classified lists of British Patents are given in lieu of a digest. These specifications are abridged in volumes published by the Patent Office. In Appendix II. the annotated bibliography in the original work has been supplemented by lists of books and periodicals dealing exclusively with the subject.

The task of revision has been somewhat formidable, and it was not intended in the first place to undertake it alone. This fact, in conjunction with existing circumstances, largely explains the somewhat later appearance of the book than would otherwise have been the case.

The reviser has to acknowledge the ready response ot

several leading manufacturers and firms in supplying information and particulars of apparatus; the valuable assistance by Mr. William Briggs, of the Inner Temple, Barrister-at-Law, in connection with Chapters IX. and X.; the help given by Mr. H. W. Heath, B.Sc., of the Patent Office, at the proof-stage, and in connection with many of the illustrations; and by Mr. Williams, of the Patent Office Library, in connection with the Bibliography; and the permission of the Controller of H.M. Stationery to utilize the illustrations published in British Patent Specifications for several of the illustrations.

It is hoped that the present work may not be too technical for the reader unacquainted with the technics of the subject, but who is in any way interested therein, and may be also useful to manufacturers and others actually engaged in the industry.

The reviser will be glad to have any criticisms and suggestions for future editions.

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LIVING PICTURES

CHAPTER I

PERSISTENCE OF VISION AND CONTINUED PERCEPTION OF THE SAME OBJECT

In all branches of applied science the reflective mind derives pleasures from tracing a perfected instrument back to its simplest form, thus separating its primary and essential factor from those mechanical improvements and additions which serve to render the apparatus perfect in action and commercially practicable. For instance, the telescope and microscope, the use of which has carried man's sight farther and farther into the boundless realms of the infinitely great and immeasurably small, derive their utility, when all is told, from the fact that a ray of light is bent out of its path when passing through any point where a change of (optical) density occurs in the material through which the ray is passing. The reason of this it is not necessary to inquire into; the experimental fact is accepted on its own merits while the possibility is admitted of some underlying verity which may prove the connecting link between this and other related phenomena, and still further simplify the expression of the natural laws governing them. And thus pursuing our present subject and considering the marvellous mechanism which brings the past in all semblance of vivacity under present view, it is only necessary to ascertain the fundamental fact which renders possible so wonderful a result. But, instead of analyzing the finished apparatus for our-

selves, it is best to take our starting-point from others, and at once prepare to follow from its primitive germ the growth of the Living Picture—a history which could never have been written were it not for the physiological phenomenon of Persistence of Vision, that basis upon which rests every one of the mechanical appliances for producing the illusion of motion which will be described.

The stock experiment which proves Persistence of Vision is of so elementary a character that man must be supposed to have noticed the effect long before he was capable of theorizing upon its cause. If a stick with lighted or glowing point is taken and whirled in a circle (an action doubtless performed in prehistoric times), it will be at once noticed, if the speed is great enough, that

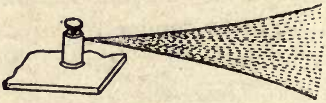


FIG. 1.

the glowing end of the stick is no longer seen as a point; but a luminous circle filling its whole path is visible instead. Again, take a flat steel spring and fix it at one end, strike the other so as to cause it to vibrate, and the spring will appear to fill the whole of the space over which it moves, as seen in Fig. 1. Now, it certainly does not require much proof that neither stick nor spring can be in two places at once; and the only possible solution of the mystery is that the luminous point or spring appears to be in any given spot after it has moved away, and continues to appear there until its return to the same position, when its image again falls on the same spot in the eye. The observer thus gets an impression of continuous presence. This taking place all along the path of the moving object naturally causes it in appearance to fill the whole

space. Fortunately this, as most other experimental facts, admits of simple verbal expression—one sentence suffices—we continue to experience the visual effect of light after it has ceased to act. This phenomenon is called, as already mentioned, Persistence of Vision, and from this point we make our departure; the investigations and theories respecting the cause of this effect, whether residing in the slow return of the brain-cells (after their excitation) to normal state, or connected with the nature of the stimulus experienced by the terminal of the optic nerve in the retina, are all interesting; but they do not alter the experimental fact of persistence, which is certainly true, even though all the theories hitherto promulgated with respect to it should prove to be erroneous.

A sentence, which is probably the first written reference to persistence of vision, is contained in the fourth book of "De Rerum Natura," by Lucretius, dated about 65 B.C. He says there: "This [perception of movement] is to be explained in the following way; that when the first image passes off, and a second is afterward produced in another position, the former then seems to have changed its gesture. This we must conceive to be done by a very rapid process," etc. Though seemingly so very *à propos*, this passage is in reality only a reference to a theory of dreams, and its interest arises from the fact that Dr. Plateau found it quoted against him (by Dr. Sinsteden) on the invention of the phenakistoscope (see *post*, p. 15); and it seems of some interest as being the first-quoted anticipation of the first living-picture apparatus. Indeed, Lucretius only expresses the *fact* of persistent vision, and mentions no *apparatus* for its demonstration.

This matter appears to have been first treated of two centuries later in the second book of Ptolemy's "Optics." This work, written about the year A.D. 130, narrowly escaped annihilation; only two copies are known to exist, and these are both Latin translations through the Arabic.

One copy is in the Bibliothèque Nationale in Paris; the other and more perfect example is in the Bodleian Library at Oxford. Ptolemy in this treatise mentions that, if a sector of a disc be coloured, the whole will appear of that colour when rapidly revolved, and if the sector be variously coloured at different distances from the centre, the disc will appear ringed. Alhazen, the great Arabian philosopher, refers to the subject about A.D. 1100, as do others, including Leonardo da Vinci, who was born in 1452. Coming to later years, Newton, Boyle, and others, mention the matter; but little practical investigation was done except the attempts by Segner, d'Arcy, and Cavallo, to measure the duration of vision after the extinction of light. To conclude the references on this subject, it is only necessary to mention that the period of persistence is now accepted as (on the average) from $\frac{1}{10}$ to $\frac{1}{24}$ of a second, subject to the degree of intensity, duration, and colour, of the light received by the eye.

Up to the end of the eighteenth century no progress was made in the *application* of the principle of persistence, and the character of last-century knowledge is well summed up in Abbé Nollet's "Leçons de Physique," 1765, tome 5, where he says: "When an object moves very rapidly before our eyes, we often attribute to it size and shape which it does not possess. A polyhedron revolved on its axis seems to us a sphere; as does also a circle revolved on one of its diameters, etc., etc." This statement merely implies the knowledge that one object may have the appearance of being in more than one place at once if it move fast enough; and here may be mentioned an old popular toy brought out by the Stereoscopic Company under the name of "The Optic Wonder." In this a piece of wire bent to the outline of one side of a vase or the like symmetrical figure was made to revolve rapidly round its vertical axis, and thereby gave the impression of a complete vessel. As an addition a glass rod,

bent to a half outline of a glass shade and mounted outside the wire, caused the appearance of a complete transparent covering. Later, a heavy metal top was used to obtain rotation, the wires being inserted in a hollow vertical spindle. This toy was manufactured in France and known under the name of "la Toupie éblouissante," or Dazzling Top (Fig. 2).

So, up to the year 1825, demonstration was confined to exhibiting *the same object in more than one place* at once; but in 1826 or thereabouts it was rendered possible to arrange *two different objects* in such a manner that they appeared to be *in the same place at the same time*. This was accomplished by the *Thaumatrope*, the invention of

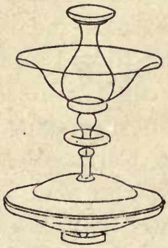


FIG. 2.

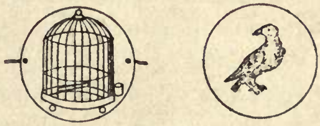


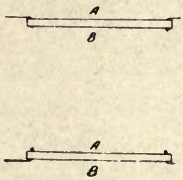
FIG. 3.

which is attributed by Brewster to Dr. Paris, who himself claimed it in his book, "Philosophy in Sport made Science in Earnest." It consists of a card having images on each surface, inverted with respect to each other, as in Fig. 3, and these images (when presented in rapid alternation by the revolution of the card) both persist, and so appear simultaneously and continuously present in the field of view. With reference to the general acceptance of Dr. Paris as inventor of this instrument (which Carpenter attributes to Dr. Wollaston), it is well to notice the following little-known story from Charles Babbage's "Passages from the Life of a Philosopher" [Autobiography]: "One day Herschel [Sir John], sitting with

me after dinner, amusing himself by spinning a pear upon the table, suddenly asked whether I could show him the two sides of a shilling at the same moment. I took out of my pocket a shilling, and, holding it up before the looking-glass, pointed out my method. 'No,' said my friend, 'that won't do'; then, spinning my shilling upon the table, he pointed out his method of seeing both sides at once. The next day I mentioned the anecdote to the late Dr. Fitton, who a few days after brought me a beautiful illustration of the principle. It consisted of a round disc of card suspended between two pieces of sewing-silk. These threads, being held between the finger and thumb of each hand, were then made to turn quickly, when the disc of card, of course, revolved also. Upon one side of this disc of card was painted a bird; upon the other side, an empty bird-cage. On turning the thread rapidly the bird appeared to have got inside the cage. We soon made numerous applications, as a rat on one side and a trap upon the other, etc. It was shown to Captain Kater, Dr. Wollaston, and many of our friends, and was, after the lapse of a short time, forgotten. Some months after, during dinner at the Royal Society Club, Sir Joseph Banks being in the chair, I heard Mr. Barrow, then Secretary to the Admiralty, talking very loudly about a wonderful invention of Dr. Paris, the object of which I could not quite understand. It was called the thaumatrope, and was said to be sold at the Royal Institution, in Albemarle Street. Suspecting that it had some connection with our unnamed toy, I went next morning and purchased for seven shillings and sixpence a thaumatrope, which I afterwards sent down to Slough to the late Lady Herschel. It was precisely the thing which her son and Dr. Fitton had contributed to invent, which amused all their friends for a time and had then been forgotten. There was, however, one additional thaumatrope made afterwards. It consisted of the usual disc of paper. On one side was repre-

sented a thaumatrope (the design upon it being a penny piece), with the motto, 'How to turn a Penny.' On the other side was a gentleman in black, with his hands held out in the act of spinning a thaumatrope, the motto being 'A New Trick from Paris.'"

To conclude the history of the Thaumatrope a reference to a suggestion made by Claudet in 1867 is alone necessary. In the ordinary form both sides of the card revolve around the same axis at the same distance, and therefore appear on the same plane. But Claudet suggested that if the card were of considerable thickness, or a substitute were provided (similar to a shallow matchbox cover), and the axis of rotation passed through one side, as shown in Figs. 4 and 5, the picture drawn on the other side (re-



FIGS. 4 and 5.

volving at a distance from the axis) would come nearer to the eye (situated either at A or B) than that through which the axis passed. One object would thus appear to stand in front of the other, giving an appearance of relief which would convert the usual form into a *Stereo-Thaumatrope.* This apparatus was designed by Claudet to demonstrate rapid alternate convergent and divergent action of the optical axes, but discussion of the questionable accuracy of his conclusions is quite foreign to the subject of this book, and finds its proper place in a stereoscopic treatise.

It is indeed strange that a toy which in the earlier years of the present generation could be bought six on a halfpenny card should have cost seven-and-sixpence at the date of its inception, and should have tempted the Royal

Institution to enter commercial life; but stranger still is the thought of that shilling, carelessly spun seventy years ago, being the first step in the long series of persistent vision apparatus whose latest developments achieve results wonderful indeed when not understood, more wonderful still when a just comprehension is formed of the numberless details which are necessary to the effective working of a living picture. However, to return to the year 1826, the date of the publication of the Thaumatrope's description. One stage in this history is here complete; Fitton's instrument set men thinking, and only six years elapsed before the first appliance was introduced for obtaining the illusion of motion.

CHAPTER II

ILLUSION OF MOTION PRODUCED BY SUCCESSIVE VIEWS OF SLIGHTLY VARYING DIAGRAMS

THE researches which led to further advance in the illusive production of motion were distributed among many scientific men, each to a great degree unaware of the others' work. The starting-point on the theoretical side was probably Dr. Roget's paper published in 1825, on the apparent distortion of the spokes of a rotating wheel when seen through a fence (*i.e.*, a series of vertical slots), a subject later investigated by Plateau. The latter, in 1836, invented the Anorthoscope, an instrument which reversed the illusion observed by Roget, and gave a correct image from a distorted original. In this contrivance a back disc bearing a distorted image revolves at a speed four times greater than a front one which is pierced with four radial slots at angular distances of 90 degrees. When in motion this instrument shows four non-distorted images formed from the one distorted original. Rose's Kalotrope (shown in 1856 at the Polytechnic) further modified this action, and caused beautiful symmetrical designs in curved lines to be produced from originals of very commonplace appearance. These instruments, though in their first forms not strictly connected with the illusion of motion, are so beautiful in their action that, depending as they do on persistence of vision, they deserve mention in case any reader cares to "look up" a subject of so interesting a nature. But in the year 1849 Plateau himself suggested a modification of this instrument which produced the illusion

of motion in a most effective manner, and this matter will be referred to somewhat later in its proper sequence.

Probably it was due as much to the invention of the Thaumatrope as to Roget's researches on the apparent deformation of the spokes of revolving wheels that attention was directed to the fruitful combined subjects of persistence of vision and rotation of a series of diagrams; for in 1831 we find several writers, including Aimé and Faraday, referring to the fact that when two cogged wheels, with equal number of teeth, revolve at equal speed *in opposite directions*, one in front of the other, the eye, if placed at a distance, perceives a stationary image of one wheel only. (Plateau had made the same observation in

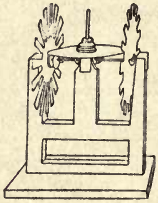


FIG. 6.

1828.) This illusive stationary wheel merely results from the strong image perceived each time the aspects of the two wheels coincide, the phase when the cogs of one wheel are passing over the spaces in the other forming, so to speak, a blurred background on which the strong stationary image stands out. To illustrate this Faraday constructed a demonstration apparatus called *Faraday's Wheel* (Fig. 6), in which two discs with notched edges were revolved at equal speeds in opposite directions by friction gearing. Faraday and Plateau both investigated the results of revolving two cogged wheels *in the same direction* and looking through the cogs of the front one at the other; in which case also an apparently stationary wheel was seen, though from a far different cause to that

in the first case, as will be seen in the following explanation of the action of a slotted disc.

Faraday also pointed out that *one* wheel gave the same result if revolved in front of a mirror, the image taking the place of the second wheel, the advantage secured being that speed of object and image were bound to be absolutely identical.

It was but a step from this discovery to the employment of a disc pierced with slots to look through and bearing radial lines on its face—*i.e.*, the side to be turned

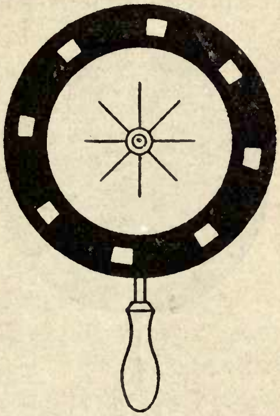


FIG. 7.

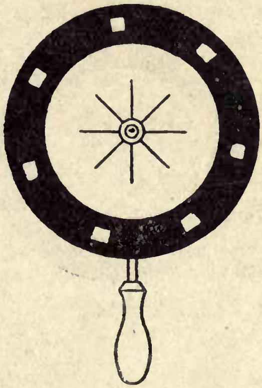


FIG. 8.

towards the mirror. From this experiment strange results followed. When the slots were equal in number to the radii (Fig. 7), the image (as seen through the slots and in the mirror) appeared stationary; when the slots were slightly fewer than the radii, the wheel appeared to travel slowly forward (*i.e.*, in the same direction as the real motion of the disc), and to move in the backward direction if the slots outnumbered the radial marks. Now, it must be understood that the disc is revolved so rapidly that if the image be viewed directly (*i.e.*, *not through the slots*) the black spokes would be confused into a grey

circle. Yet when seen through these small openings every individual spoke appears distinctly, a fact which points out the slots as the key to the mystery. The reason is simple. Every time a slot passes the eye an impression is received of the image of the whole face of the disc (as seen in the mirror), and though the whole image is turning rapidly, the slot (if narrow) goes so quickly past the eye that the image has not time to move far enough to give any impression of motion, and therefore it appears to be standing still. If, now, when the second slot passes before the eye the image presents a precisely similar view

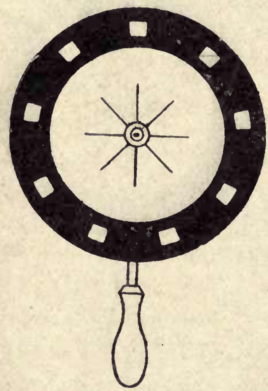


FIG. 9.

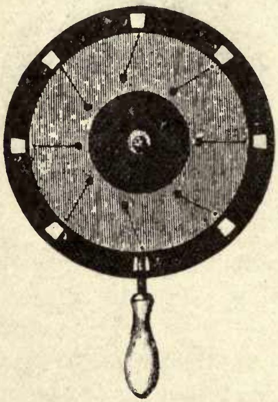


FIG. 10.

to the previous one (and this is the case when radii and slots are equal in number), it is obvious that it will not appear to have moved at all; for we shall have combined *two successive similar images*, by the action of persistence, into *one permanent impression*. If, however, the slots are fewer in number than the spokes (Fig. 8), when the second slot comes before our eye, the second spoke, instead of falling in the same place as the first, will be seen slightly in advance of that spot, and will thus give the impression that the first spoke has moved forward a little. If, however, the slots are more numerous than the spokes (Fig. 9),

we receive our second view a little before the second spoke has arrived at the spot where the first was seen, and we therefore imagine the first spoke to have moved back to that extent. It will now be clear that the whole phenomenon depends on the fact of the moving image being seen for so short a period that it appears to be still; during the time it is *not* seen another image takes its place, and this substitution is effected so rapidly that the first image persists in the eye until the second one is presented to view, this order of things being repeated with succeeding images so long as the disc is turned.

Suppose, now, instead of a series of *similar* images we have a succession of slightly varying drawings (say of a man) in which while the body agrees in all, yet the arm is in different positions, such as lifted gradually higher and then dropped so that the last of the series nearly agrees with the first. In this case repeated views of the body will all agree, but the arm will be seen, first low down, then gradually rising, then falling and rising again; persistence of vision blending the images, so that the action appears continuous although we really see it in jerks. And here we have the true living picture, capable of improvement no doubt, needing instantaneous photography to confer accuracy, requiring extreme mechanical perfection to secure a sufficient number of pictures in a second and to again combine the same into one continuous scene; but yet, from this point onward, there is little discovery to record, though many ingenious inventions remain to be described. These inventions naturally aimed at one result, but by different methods, and therefore the history of each class of device must be separately traced.

The instrument which has just been referred to as the progenitor of all these species was invented simultaneously by Plateau of Ghent and Stampfer of Vienna; and though their instruments were identical they naturally

received different names from their respective originators. Plateau forwarded an example of his *Phenakistoscope* through Quetelet to Faraday in November, 1832, his letter being printed in February, 1833. Stampfer first made his *Stroboscope* in December, 1832, at which date no description had been published of Plateau's previously constructed Phenakistoscope. As an early instance of confusion of terms it may be mentioned that Snell, writing in 1835, calls the Stroboscope by the name of *Phantascope* or *Kaleidorama.* Müller in 1846 applied this instrument for the demonstration of wave-motion, and Poppe, Savart, and others, employed it for the synthesis of other natural motions. One application is shown in Fig. 10, where a pendulum appears to swing as the successive stages of that action are momentarily perceived through the slots by means of a mirror. It will be understood that, while the slotted disc is of metal, the diagrams are drawn on a circular removable card, in order to allow the inspection of varying subjects. One later and very interesting form of this instrument may be mentioned here. Lommel in 1881 suggested that a strong beam of light might be thrown, from behind, through the disc by means of a lens bringing the beam to a focus in the slot. In this way a powerful illuminating beam was passed through a very narrow opening, and as it again spread out a mirror reflected it on to the surface of the disc, as seen in Fig. 11. When the disc was in rotation the light only fell on the designs in intermittent flashes as each slot allowed the beam of light to pass. The result of interrupting the light in this way, instead of by a slotted disc between the eye and the design, was to render it possible for a whole roomful of people to see the entire disc at once, whereas with the older arrangement only a single person could view the effect at one time.

The slotted disc was, however, felt to be a great disadvantage by reason of the small amount of light which

could reach the eye; an idea of the proportion allowed to pass may be formed from the relative extent of slot and opaque disc, for of course while the latter is before the eye no light is received. Wheatstone endeavoured to overcome this failing by allowing the disc to be viewed on its face instead of in a mirror. By means of a cog and snail motion the disc was kept at rest for a comparatively long period and then rapidly jerked into its next position. The eye was thus impressed with a vigorous image which persisted over the short period of blur caused by the rapid movement, and then received the succeeding stationary image in its full strength.

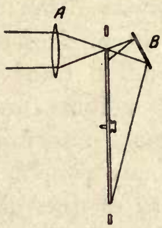


FIG. 11.

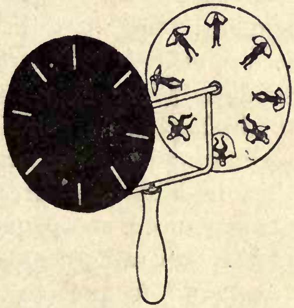


FIG. 12.

This crude apparatus is interesting because of the employment on some of the more modern machines of an intermittent motion with such a long rest and such rapid travel that a shutter is dispensed with; while one form of apparatus manufactured in France actually took its name of Héliocinégraphe from the very same cog and snail motion employed by Wheatstone fifty or sixty years ago. It was subsequently suggested, in order to obviate the use of a mirror, that a slotted disc might be mounted in advance of the diagram but on the same axis, so that they both revolved in the same direction at the same speed (Fig. 12); and though this

form of apparatus did not make its commercial appearance till somewhat late in the day, it will be seen from the drawing that the arrangement is exactly equivalent to viewing the back of a slotted disc in a mirror. It, however, opened the way for further improvement by exhibiting clearly the shutter-like nature of the slotted disc.

The first attempts at projection were founded on this type of machine, the design wheel being transparent and light thrown first through it, then through the slots, and finally on to the screen by means of an objective. This was done by Uchatius between 1851 and 1853, but Plateau himself had practically attacked the same problem in 1849 in a modification of his Anorthoscope (see p. 11). It will be remembered that the Anorthoscope produced four non-distorted images from a distorted original. Plateau placed sixteen images in progressive series round the margin of a glass disc, and in front of this, in a reverse direction, revolved, at a four times greater speed, an opaque disc with four slots. The front of the apparatus could be observed by many people at once, and to prevent confusion the parts of the disc showing the non-erect images were screened off. It will be seen that as a slot passed ne aperture in the screen one image would be viewed and the light then cut off while the transparent disc turned one-sixteenth of its diameter and the opaque one one-quarter. The next image would then be revealed, by its coincidence with the slot, in the same position as that in which the previous image was obs.rved.

Plateau seemed very proud of the sensation caused by his first design (drawn to his request, for by this date he was unfortunately stone-blind). It represented a devil blowing up a fire, and the effect was so striking that Plateau was led to further suggestions of a photographic character, which will be referred to in their proper place.

It is plain that to render this apparatus available for projection it but required a condenser behind the transparent disc and an objective in front of the opaque one; but Plateau does not appear to have suggested this, and the first application of differentially speeded discs to the purpose of projection-work appears to be the *Lantern Wheel of Life*, an instrument of considerably later date. The Austrian Lieutenant (subsequently General) Franz Uchatius wrote, on February 16, 1851, a letter to Prokesch, the head of the Viennese optical house subsequently known by the name of Fritsch. In this letter he refers vaguely to the glories of the Phenakistoscope having been surrendered, and his subsequent papers show that the manufacture of his instruments was entrusted to the above-mentioned firm. The first form attempted was an arrangement exactly similar in principle to Fig. 12, the light being thrown through a transparent design disc on to a screen by means of an objective, the slotted disc acting as a shutter. The loss of light proved to be enormous; figures of greater size than 6 inches could not be shown; and Uchatius was led to invent, and Prokesch to manufacture, an apparatus of an exceedingly ingenious and interesting nature, which was shown at the Vienna Academy of Sciences in 1853.

In this later form the diagrams were painted on the circumference of a transparent disc, which remained stationary. In front of each design a lens was placed, the whole circle of lenses being capable of adjustment in order that all the optic axes should cross at the place where the image was formed on the screen. The separate lenses thus all threw their respective diagrams in the same place, the succession of the series being attained by revolving a limelight behind the diagrams, only one of which was thus lit at a time. The interest of this apparatus is great, not only from the fact that the source of light was the only moving part, but also because this

appears to be the first suggestion of projecting successive pictures through more than one optical system. Instead of moving the illuminant, it would have been simple to have deflected the light by means of a rotating mirror, but this multiple form does not appear to have been followed up, and though in any type of slotted machine with continuously moving diagrams the loss of light must have been enormous, yet it was towards the improvement of this type that attention was directed. To secure increase of illumination it was necessary to show the object for as long as possible, making the change to the next diagram in a very short time. This desire mainly arose because the need for a projecting instrument was strongly felt

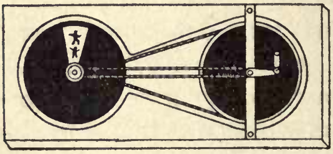


FIG. 13.

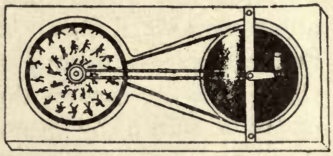


FIG. 14.

and it is certain that no toy attains a great popularity whose use is confined to one individual at a time.

The most effective early device for this purpose was the Ross *Wheel of Life* (Figs. 13 and 14), designed for use in the Optical Lantern, and patented in 1871. The disc bearing the figures is caused to revolve slowly; the opaque disc has one sector removed and travels at such a speed as to make one revolution while the transparent disc moves one stage. Thus in Fig. 13 two figures are seen through the opening in the opaque disc. Its revolution promptly cuts them out of sight, and by the time the opening comes back to the same place the next pair of figures (in slightly different attitudes) are found to occupy the same vertical line. This arrangement is practically a substitution of a one-slot disc for a four-slot one as used by Plateau in the instrument last described. The result of this arrange-

ment is that the lantern screen is full of figures all in motion and in various phases of the same action; but this multiplicity of images is confusing, and attempts were made to show only one figure on the screen at a time. Mr. Beale, of Greenwich, devised a method whereby a face could be shown in motion by means of a series of sixteen pictures illuminated by intermittent flashes. A painting of a human bust was made on a screen, the face being replaced by a hole, behind which could be brought sixteen views of a face in the various stages of a grimace or smile by means of the revolution of a disc on the circumference of which they were painted. A sixteen-holed shutter worked by gearing admitted a flash of light to illuminate the painting for a moment as each face arrived in its proper position, the light being cut off during a quick change to the next expression. By means of an ingenious contrivance which allowed only every alternate opening in the shutter to act, and was adjustable to show first one series of eight and then another, the resultant grimace was varied in a most amusing way. This arrangement, however, needed a full-sized painting for every effect, and was not of the ordinary magic-lantern nature; the separate pictures not being projected, but only illuminated intermittently.

A single and therefore larger figure than that given by the Wheel of Life was subsequently projected on the screen by the same inventor, whose "Dancing Skeleton" was a great success. A disc was used, rotating in front of a lantern condenser; but this disc, instead of being formed of glass, was of thin sheet metal, the figures of a skeleton in various attitudes being cut out, stencil fashion, round the margin. These necessarily brilliant white figures were projected on the screen in the usual way by an objective, the light being cut off by an interruptor (geared from the axle of the disc) during the period of change. Mr. Beale also constructed this instru-

ment with the stencil figures on a long slip, performing the necessary eclipses by a rising and falling shutter, the whole arrangement being called by him the *Choreutoscope*. An improved form of this device was patented by Hughes (1884), and is applicable to any ordinary optical lantern. Fig. 15 shows the working parts. Turning the handle revolves a disc, a pin on which raises the shutter and so interrupts the light. Teeth on the disc then come into play, shifting the long slide one stage, and so soon as it comes to rest the shutter drops and exposes the picture. A continuous motion of the handle repeats these actions with sufficient rapidity to throw an apparently permanent and moving figure on the screen. A somewhat similar

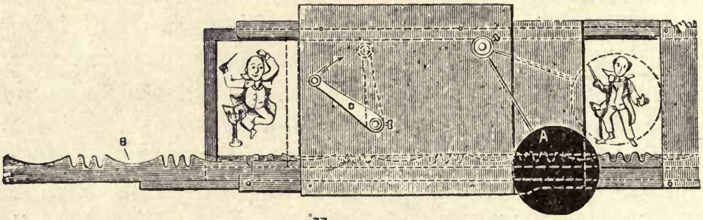


FIG. 15.

arrangement to Beale's Rotary Choreutoscope was patented in the United States by A. B. Brown in the year 1869 (No. 93,594); see pp. 51, 132. This specification is mainly of interest by reason of the construction employed in the intermittent mechanism. It forms a very close approach indeed to the modern cinematograph with Maltese Cross motion; a star-wheel and pin being used to drive the design-wheel periodically, while a two-sector shutter is shown geared to eclipse the light during the change of picture. From this point it would be comparatively easy, by describing no more than two machines, to bridge the gap of twenty years which still remains to be traversed ere the first machine of distinctly modern type appears. Mr. Heyl, in the year after Brown's United

States patent, exhibited a somewhat similar apparatus, employing photographic images; but consideration of his machine must be deferred until the next chapter, for many elementary forms of apparatus remain to be described before the subject of chrono-photography is discussed.

Of the simpler diagram apparatus, however, the phenakistoscopic, or disc-and-slot machines, are practically exhausted, except so far as their principles may recur in some form of photographic device, and it is necessary now to consider the cylindrical apparatus (directly derived from the Phenakistoscope), popularly introduced about 1860, and subsequently called the *Zoëtrope*, *Zootrope*, or *Wheel of Life*, the latter term being a name also applied to a previously described lantern slide (p. 20). Desvignes patented the Zoëtrope, though not naming it, in 1860. The year 1867, however, saw a patent (No. 64,117) issued in the United States to William E. Lincoln, of Providence, U.S.A., for the selfsame contrivance under the name of *Zoëtrope*, apparently the first use of the word. But this type of slotted machine takes its origin at a date far anterior to those quoted above; in fact, only a little more than a twelvemonth elapsed between the invention of the phenakistoscope (1833) and publication of the following suggestion by W. G. Horner in the *Philosophical Magazine:* "The apparatus is merely a hollow cylinder, or a moderately high margin, with apertures at equal distances, and placed cylindrically round the edge of a revolving disk. Any drawings which are made on the interior surface in the intervals of the apertures will be visible through the opposite apertures, and, if executed on the same principle of graduated action, will produce the same surprising play of relative motions as the common *magic disk* does when spun before a mirror. But as no necessity exists in this case for bringing the eye near the apparatus, but rather the contrary, and the machine when revolving has all the effect of transparency, the phenomenon may be

displayed with full effect to a numerous audience. I have given this instrument the name of *Dædaleum*, as imitating the practice which the celebrated artist of antiquity was fabled to have invented, of creating figures of men and animals endued with motion. . . . I have not thought it requisite to give a more particular description of the instrument, having communicated every needful part of the detail, some weeks ago, to a respectable optician of Bristol, Mr. King, jun."

This is an absolutely correct description of

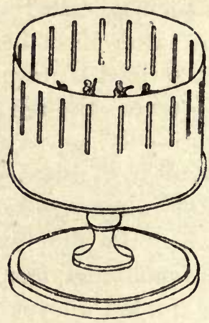


FIG. 16.

the instrument patented by Desvignes twenty-four years later, and known under the name of the Zoëtrope. The apparatus, in its modern form, is shown in Fig. 16. A band of figures having been placed inside the cylinder, the whole is rotated, and the figures are then seen in motion. The series of figures is such as shown in Fig. 17, which forms a very good example. The bodies, being equal in number to the slots, appear to remain in the same place although legs and arms are in motion. But the number of heads being one less than the slots, the whole series appears to have a slow motion in the reverse direction to that in which the

FIG. 17.

Zoëtrope is turning (*cf.* Fig. 9). The effect is therefore that of a row of dancing figures, perpetually trying on heads and then passing them to their neighbours, who repeat the same antics. The variations between successive figures are better seen in Fig. 18, taken from Brad-

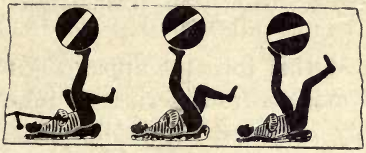


FIG. 18.

ley's English Specification, dated 1867. As shown in his engravings the modern Zoëtrope is a moderately high cylinder, the slots being placed in the upper part. The first commercial form, however, though the same in principle, differed from this plan in construction. No drawing

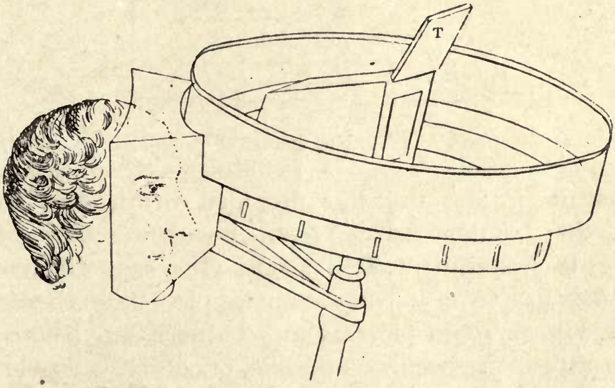


FIG. 19.

of Horner's Dædaleum appears to have survived, but the Desvignes' designs are of great interest, as foreshadowing many later inventions, and reference will frequently be made to his various suggestions. Fig. 19 shows his arrangement of the slots *below* the design, a kind of casing,

T, in the interior of the cylinder, being fixed in such a manner that it does not revolve, and serves the purpose of limiting the field of vision. By the simple expedient of turning the cylinder on its side the apparatus was adapted for the exhibition of stereoscopic views, as seen in Fig. 20, a suggestion being made that transparent images might be employed.

Anschütz used this form of apparatus to produce the appearance of motion from series of animal movements photographically obtained. It will be seen that when diagrams are *drawn* the cycle of movement can be completed in a given number of pictures, and the older form

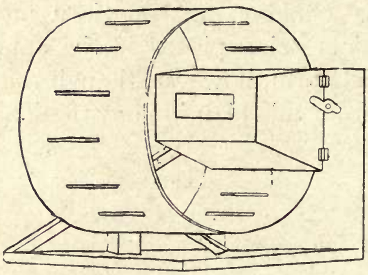


FIG. 20.

of instrument was therefore provided with a fixed set of slots, the diagrams being prepared with a sufficiency of figures to obtain the desired result. It is very different in the photography of moving animals. In taking these, six, eight, ten, or more pictures may be necessary before the same attitude re-occurs; and this, of course, is absolutely necessary to enable the last picture to run on to the first and give an endless repetition of the same movement. Anschütz was thus obliged to form his Zoëtrope (called by him the *Tachyscope*) as a very shallow cylinder, into which could be inserted a long strip bent round to form the walls. This strip bore the required number of images to complete a cycle of movements, and was pierced with the

number of slots necessary to give a correct effect with the number of pictures in the series. Marey not only used photographs but also actual models, on a small scale, of such animals as he desired to show in motion. One of these *Stereo-Zootropes* is still preserved at the Paris Physiological Station, and by the continued observation of successive models in different attitudes the effect is produced of an actual animal running, or bird flying round the interior of the cylinder. In this connection it is interesting to refer again to Desvignes, whose 1860 Specification shows a *Zoëtrope* employing solid models. By the construction of his apparatus (Fig. 21) the figures were placed on the margin of the cylinder rather than in its interior, but the idea is essentially similar to Marey's.

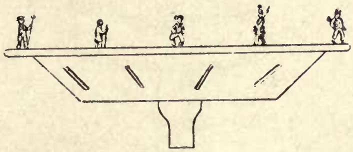


FIG. 21.

Now, one great defect of this, as indeed of every other instrument where the object is in motion while seen through a slit, is distortion. When the object and slit are travelling in the same direction (as in the Phenakistoscope) the object appears elongated ; when the reverse is the case (as in the *Zoëtrope*) it appears compressed in the direction of its length. Plateau in 1849 had recognized this difficulty, and therefore prepared his diagrams in a form purposely distorted in an opposed sense to the distortion caused by the revolving disc, one distortion thus neutralizing the other. This defect led Clerk-Maxwell, in 1869, to propose the substitution of concave lenses for the slots, their focal length being equal to the diameter of the cylinder. The virtual image of the design opposite the lens was thus formed exactly midway between lens and

picture, and this spot necessarily coincided with the axis of rotation. That being the case, the successive images were perceived in one and the same spot, and remained stationary during the whole time they were individually exposed to view, the movement of the lens being neutralized by the movement of the real object on the other side of the cylinder. It will be seen that the distortion common to all ordinary types of slotted machines was thus done away with, and at the same time the images appeared more brilliant—a wide lens being substituted for a narrow slot. Maxwell used this device for combining series of diagrams of many physical phenomena (such as smoke-rings, etc.), in order to show the resultant move-

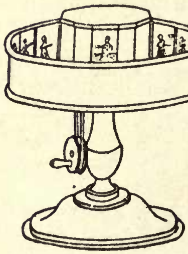


FIG. 22.

ment, but the apparatus does not seem to have come into general use.

In the year 1877, however, Reynaud patented a contrivance which attained almost instant popularity under the name of the *Praxinoscope* (Fig. 22). In this instrument the pictures are not directly viewed, but are seen in a mirror, the picture under observation thus being the one nearest the observer instead of that on the opposite side of the cylinder. It will be seen that the pictures are arranged on a slip placed round the interior of a drum much more shallow than that of the Zoëtrope, and the centre of the cylinder is occupied by a set of mirrors, equal in number to the diagrams, and arranged in polygonal form, the said polygon having a diameter half that of the

cylinder. Now, as the picture is a quarter-diameter in front of the mirror, its image will appear the same distance behind, exactly on the axis of rotation, the one immovable spot in the whole apparatus. A reference to Fig 23 will make the action clear. O is the centre of rotation ; A, B, E are two mirrors, and C, D, F the two pictures opposite them. When a picture is in the position S′, S, the mirror T′, T directly faces the eye, and the image is perceived as if it were at D‴, C‴, its vertical central line coinciding with the axis of rotation. It will also be seen that a picture at C, D forms its image at D′, C′, and a picture at

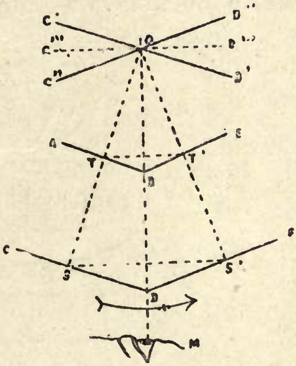


FIG. 23.

D, F forms its image at D″, C″. In all these cases the central lines of the various images agree, and manifestly they will not appear to shift their position as a whole on the change from one attitude to another. Further, when the apparatus is in the stage shown by heavy lines (that is to say, with the eye looking between the pictures on to the junction line of two mirrors), half of one image will be seen in one glass and half in the other, thus making up a complete image from the combined halves ; the appearance given when in action being that of a series of plain glasses passing between an immovable image and the eye. Here, then, there is no interruption of the light, and the

brilliancy of the image is so much the greater, while its stationary position obviates that distortion which forms so great a disadvantage in slotted machines. Reynaud suggested an adaptation for stereoscopic purposes (Fig. 24), but this does not seem to have been carried out.

Several ingenious additions to this instrument were, however, subsequently made by the same inventor. One, shown in Fig. 25, and called the *Praxinoscope Theatre*, was designed to show a moving figure on a stage. The praxinoscope was screwed into position in the bottom portion of a box, through the lid of which (standing at right angles) an inspection opening was provided. Between

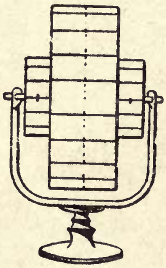


FIG. 24.

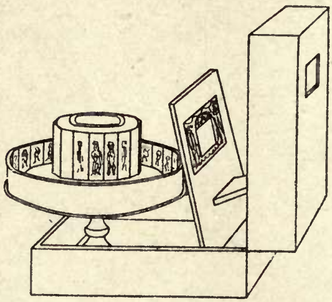


FIG. 25.

this opening and the praxinoscope a sheet of glass, bearing a painted proscenium, was held at a slight angle, the opening of the stage being left clear. On the interior of the lid changeable pictures of scenery could be placed, and were seen reflected in the glass as if they were really in position behind the stage-front. At the same time the moving figures in the praxinoscope (strongly illuminated and drawn on a black background) were seen *through* the transparent mirror, and thus appeared to be in motion on a stage provided with scenery. This result was also obtained in another manner, which permitted a large number of observers to see the effect at once. A kind of

double magic-lantern (Fig. 26) was used, one member of which threw some scene on the screen in the ordinary way, while the other projected a beam of light through pictures on a transparent praxinoscope drum. On leaving the pictures, this light was reflected from the specially angled central mirrors through a lens on to the screen, where it formed an image of the moving figure superposed on the scenery thrown by the other objective. This apparatus was called the *Projection Praxinoscope*, or *Praxinoscope Theatre.*

In 1889 M. Reynaud patented another form of instrument, which permitted the employment of much longer

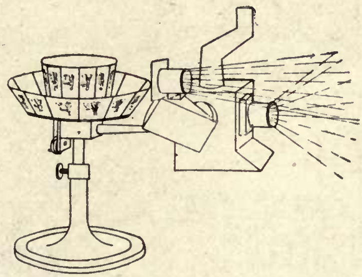


FIG. 26.

series of pictures. In the previous form the length of the series was limited by the size of the drum. It will be seen by Fig. 27 that the subsequent method permitted a long band to be wound from one reel to another, passing over a skeleton drum on its way. The principle of projection was the same as in the earlier instrument, the permanent scene being thrown by a lantern, L; while another source of light, L′, projected a beam through the picture on to the central drum (of the usual praxinoscope type) from which it was reflected, the mirror M again diverting the light through the objective O. Another mirror changed the direction of the rays and threw the moving picture on the screen. An endless band per-

mitted the use of a comparatively long repeating series, while the length of a non-repeating scene was only limited by the size of the spools and the cost of preparing so large a series of pictures. Under the name firstly of the *Praxinoscope Projection Theatre* or *Optical Theatre*, and subsequently under that of the *Theatriaxinoscope*, this apparatus appeared on the Paris boulevards. A serious disadvantage

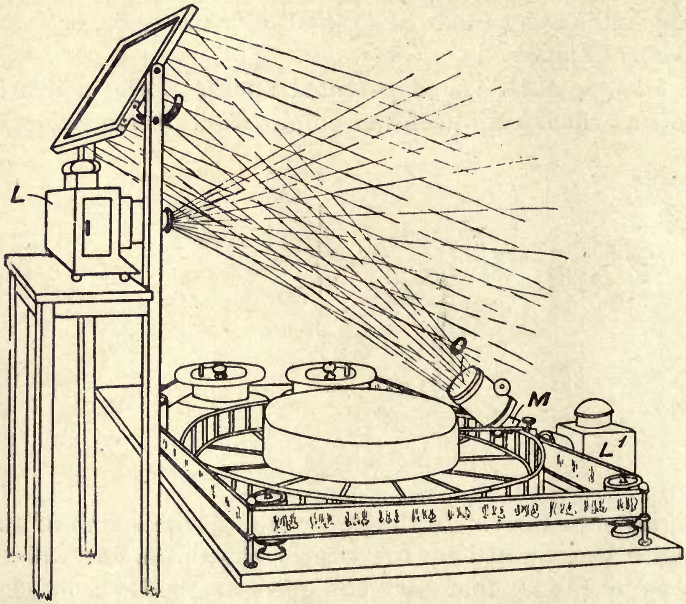


FIG 27.

of this form of Praxinoscope must be referred to. The band is necessarily vertical, the objective sloping. This militates against the sharpness of the projected pictures, while the light being reflected from the drum, and again diverted by two more mirrors, all tends to degrade the clearness of the final image on the screen. But even with these imperfections this arrangement marks the culminating point in the development of the Praxinoscope

type, another form of which instrument, devised by the same inventor, deserves mention from its extreme simplicity. It was called *La Toupée-fantoche* or *Marionette-top*, and, as seen in Fig. 28, consisted of four mirrors arranged as a pyramid and surmounted by an interchangeable card bearing four designs. The whole was placed on a spindle, and, when rotated, gave a moving image on exactly the same principles as those governing the more elaborate devices previously described. This cylindrical type of apparatus has subsequently been the theme of many inventions, but has not come into extensive use, owing largely, no doubt, to the development of the more convenient film machines.

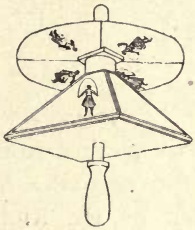


FIG. 28.

Another class of device, employing diagrams with a view to producing illusive motion, necessitates a considerable chronological backward movement for its origin. Returning to the Thaumatrope, it will be remembered that both sides of the card are perceived at one and the same time; the card revolves so rapidly that each picture comes back before its image has faded from the eye, and therefore both appear present at once. It will be conceded that the same effect would be produced if the axis of revolution were vertical instead of horizontal, and, in fact, this form of Thaumatrope has been used for demonstration purposes (Fig. 29), while a penny street novelty of June, 1898, shown in Fig. 30, is but a similar instrument rotated by vanes and a blowpipe. Now, it is

apparent that if the second picture did not come into view until just as the first was dying out, and remained in sight after the first had entirely faded away, then, under such circumstances, the two views would not be concurrently

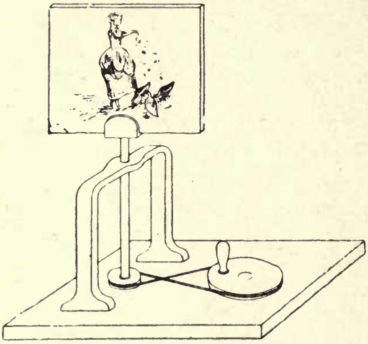


FIG. 29.

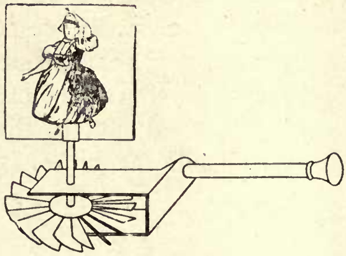


FIG. 30.

perceived, and the first picture would have appeared to have changed into the second. A toy based on this principle was invented by Dr. Richard Pilkington. As

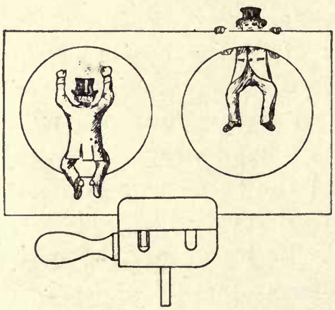


FIG. 31.

shown in Fig. 31, the *Pedemascope* is fitted with a design giving the effect of jumping, an action from which its name is derived. A card bearing the two extremes of a movement printed on its two sides was mounted in a

wooden holder by means of a longitudinal groove, and the holder was rapidly twirled between finger and thumb, backward and forward, through a half-revolution, by means of an axial pin projecting through a handle. Stops were arranged on this latter to prevent the card exceeding the necessary half-turn, and the apparatus may be considered as one of the most simple for exhibiting the illusion of motion.

In 1868 Langlois and Angiers invented and patented a means of rapidly alternating two microscopic views by means of a pushing-piece, the views returning by the spring of a block of rubber against which they were mounted. This device they named the *Kinéscope;* and a

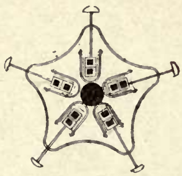


FIG. 32.

FIG. 33.

multiple form, designed for a watch-chain charm, is shown in Fig. 32. Their specification also refers to this device as the *Photoscope.* Another example of this two-diagram class is the ordinary magic-lantern *Slipping-Slide.* One glass bears a figure with, for example, his legs in duplicate, one set being raised and the other lowered, as seen in Fig. 33, wherein a clown is painted on a black background, and over him slides a second glass bearing two black patches so arranged that one of the legs is covered while the other is in full view. By a to-and-fro motion of the slipping glass the two differently-posed legs are alternately shown, with the apparent result of a gymnastic performance, which may be varied by the action of a second slipping glass arranged to alternately cover and

uncover the duplicate lower portions of the raised legs, which then appear to work from the knee.

Another toy, shown in Fig. 34, is of a very simple nature. A vertical spindle carries a set of four cards, projecting radially at angles of 90 degrees, the whole set being united and capable of rotation. In the four angles between the cards four successive positions of the same figure are shown. The set of pictures is rapidly rotated by the cards acting as vanes when blown upon, and it will be seen that one figure is observed when an angle is

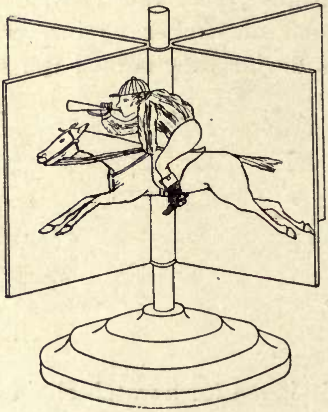


FIG. 34.

opposite the eye, while a picture compounded of the left-hand of one design and the right-hand of the next is seen when a card stands "edge-on." A further development of this was patented in 1895. The cards are independent, and, instead of travelling at a fixed rate, are stopped back, but when released fly over quickly by reason of their spring connection with the central rotating shaft. Though the inventor designed this apparatus as capable of rapid action, it is not in fact so employed. It may be seen frequently, working slowly, as a kind of revolving album in photographers' windows.

When a large number of leaves are used, apparatus of this character naturally takes the form of a book, in which the bent-back leaves bearing the series of designs are presented to the eye in rapid succession by their escape from under a slowly-drawn-back thumb. The first suggestion of this kind appears to be due to Linnett, who in 1868 patented his *Kineograph* (Fig. 35). He also suggested the use of mechanical appliances for turning over the leaves, but showed no such arrangement. The book idea (patented again in 1886) had a considerable

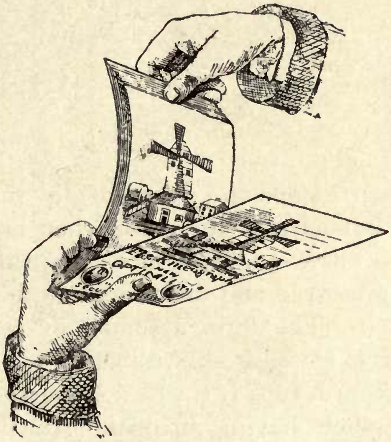


FIG. 35.

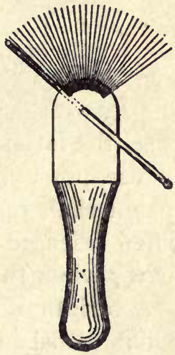


FIG. 36.

revival of popularity in 1897 (in which year another patent was granted for an apparently similar device) under the title of the *Pocket Kinetoscope*, half-tone photographs being employed instead of drawings. Book-form apparatus were also brought out in France by a M. Watilliaux under the name of *Folioscope*. A kind of clip was patented in 1896 (No. 20,136) as a substitute for the thumb, and as a means of providing more regular action. A suggestion by Casler provides for the cards being mounted radially on a wooden holder instead of being bound in close contact (Fig. 36), and a bent-wire

lever bears on the upper portion of the cards in order to gradually release them as it passes over. One of the most perfect, and at the same time most compact, apparatus in book form is Short's *Filoscope*. The book was bound in a metal clip pivoted in a metal casing, and could be revolved by pressure on an attached lever, as seen in Fig. 37. The leaves are released in regular succession,

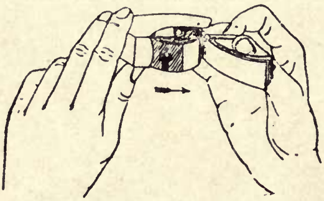


FIG. 37.

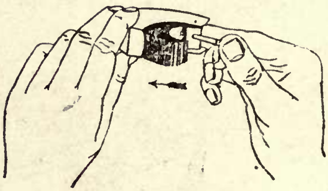


FIG. 38.

and fly over rapidly on their escape from the edge of the case, the latter being so formed that the cards when not in use possess a concave curve on their face. By this means their resiliency is preserved and their rapid motion when released is increased. The form assumed by the leaves when the apparatus is closed is shown in Fig. 38.

A variation of this book-form type is Casler's *Mutoscope*, which consists of a receptacle having an opening in its

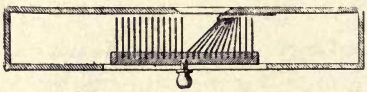


FIG. 39.

face, under which a set of cards are passed, these being arranged in a series on a flat plate. This plate can be slid along the interior of the receptacle by means of a handle passing through a slot, as seen in Fig. 39, and each card is held back by a stop in order to allow it to be inspected. When the edge of the card is drawn over the stop, the whole rapidly flies past the opening into its

normal position, leaving the next picture in full view. Another form of this apparatus is shown in Fig. 40, where the cards are seen mounted on a band in such a manner that one only projects from the top of the casing at a time. The whole series may be pulled over at any desired

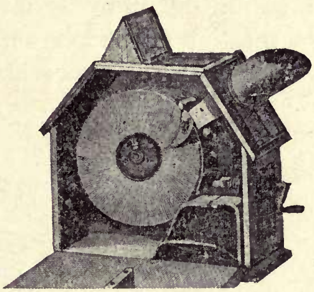


FIG. 41.

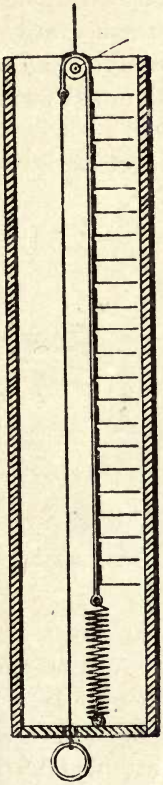


FIG. 40.

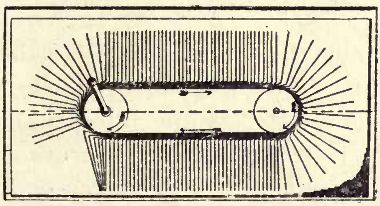


FIG. 42.

speed by means of a ring shown at bottom, the band of views being returned by the action of an opposed spring.

A more compact arrangement, and one permitting continuous repetition of a series, is that in which the pictures are mounted on a revolving axle. Fig. 41 is a view of an

instrument invented by the same man, and called by the same name as the preceding apparatus. A series of cards sufficiently numerous to permit the representation of a continuous scene is mounted radially from an axle. These cards bear photographic enlargements 6 by 4 inches, and the whole may be rotated at any desired speed by means of a handle. Each picture is arrested momentarily by a stop, thus allowing the picture to be distinctly seen, and then permitting it to fly into its normal radial position as the rotation of the axle sets its edge free. The patent (No. 14,439 of 1895) provides that a longer series may

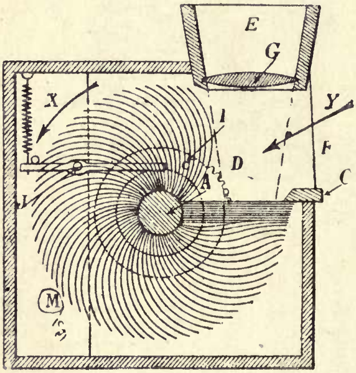


FIG. 43.

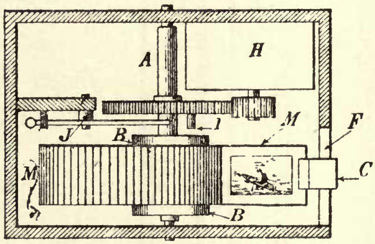


FIG. 44.

be mounted in helix on the axle, which then must be so arranged that it moves slowly sideways. A subsequent patent suggests the interposition of resilient leaves between the picture cards in order to increase and preserve their spring, and the same end may be attained by the method of mounting shown in Fig. 42. It will be seen that the form of card adopted carries the picture at a tangent, and it therefore flies over rapidly without requiring resiliency, a property not always possessed by those materials best fitted for printing on, and which is at the best somewhat difficult to maintain in apparatus in constant use. A large number of these Mutoscopes,

worked on a coin-freed principle, formed one of the features of the Photographic Exhibition at the Crystal Palace in May, 1898. Messrs. Lumière's *Kinora* (Figs. 43 and 44) is very similar in principle, but varies in a few details, mainly directed towards the important matter of resiliency. The pictures are mounted on flexible supports, blackened on the back to obviate reflection of stray light, and these supports possess a curved form. The cylinder is rotated by a clockwork motor, H, so as to

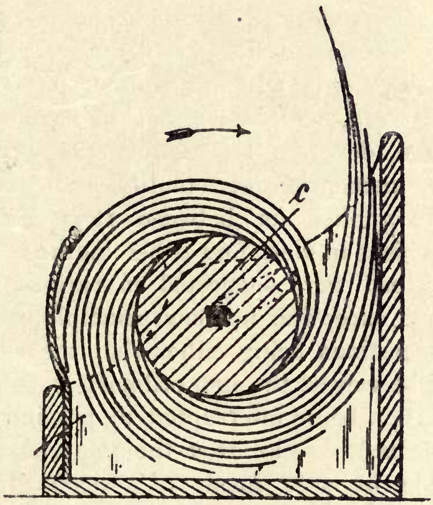


FIG. 45.

bring the concave sides of the pictures towards the inspection lens inserted through the top of the casing. A stop, C, arrests the pictures before they reach the lens, to the axis of which they are held at right angles, the curve in the flexible support straightening out to compensate for the rotary movement of the axle. Each picture therefore lies perfectly flat for inspection, and then flies rapidly past the lens, returning to its proper radial position and curved form by virtue of its elasticity. The

apparatus may also be set in motion by hand, and if more than one scene is depicted in the series an automatic stop, J, is provided. A simple form of this type is shown in Fig. 45. The cards, tangentially mounted, are held back by a guard, and when released fly into an upright position for inspection, their vertical situation being maintained by a wall against which they rest until covered by the next picture.

One early application of the Phenakistoscope and Zoëtrope must be referred to, but the idea never brought forth any very practical results, though many minds attempted a solution of the problem. A glance at the lists of British patents, and the Bibliography given at the end of this work, will show that in early years great attention was devoted to methods of attaining the simultaneous perception of solidity and motion. Six patents were applied for between 1853 and 1860, all having this object in view, and other methods than those therein described were suggested in various periodicals. With but one exception no new principle was involved, the only suggestions being either that the edges of two discs should be viewed through ordinary stereoscopic eye-pieces (the vision being interrupted by passing slots on an independent disc), or else that the two views should be mounted side by side inside a horizontally revolving cylinder slotted in the usual way, an arrangement merely equivalent to a Zoëtrope working on its side, as was shown in Fig. 20. The exception referred to is the principle, suggested by Claudet in 1853, of allowing only one eye to perceive one view at one time, a slightly different design being presented to the other eye just previously to the first being cut off. A continuous yet progressive image is thus presented to the brain by means of images impressed alternately on the two eyes and over-lapping in point of time. Other methods involved the principle of projecting one picture on the screen from one

lantern before the previous view is shut off in the other, thus presenting a continuous picture equally to both eyes. With this method there is an inevitable unsteadiness in the near foreground objects on the screen, owing to the photographs being taken alternately from adjacent positions.

Two other methods of changing the picture stand by

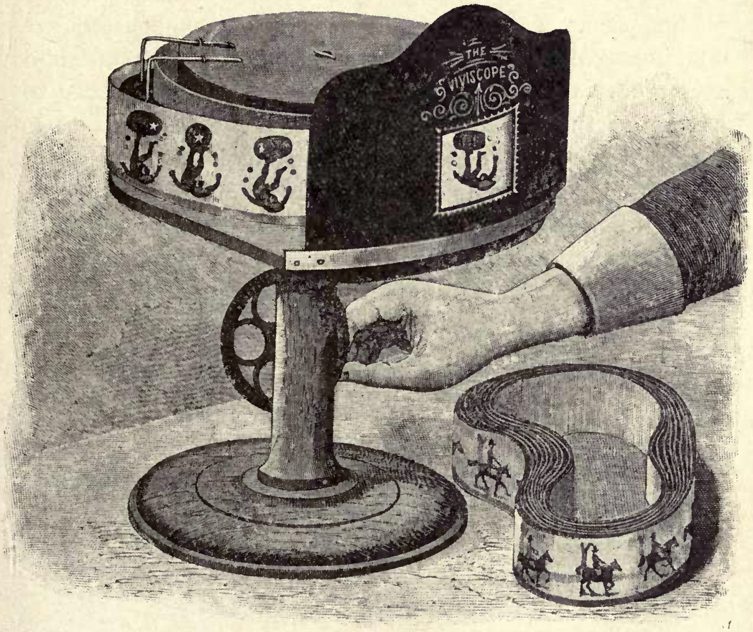


FIG. 46.

themselves. The first is the *Viviscope* (Fig. 46), in which a band bearing a series of diagrams is in tight contact with a large cylinder except where a small interposed roller bears it off. This small roller travels round under the band, which remains stationary while in contact with the large cylinder. Each time, however, that the small roller passes any point the band returns to contact with

the large cylinder in advance of its previous position. The diameter of the roller is so proportioned that the length of this advance is equal to the distance necessary for the substitution of the next picture. A reference to Patent 2,623 of 1890 will conclude the description of these more or less primitive diagram forms of apparatus. It is a method of substituting one picture for another by means of sectional change over all its surface instead of displacing it as a whole, and the methods suggested are ingenious, although the device apparently has not had a commercial career. The first stage of the History of Living Pictures is now at an end; the early short-cycle devices have been described, and though some of them have in their development attained a considerable degree of progress, yet without photographic aid it is most probable that they would not have reached so high a degree of efficiency. Thus, the final evolution-stage of the Living Picture commences with the rise of Chrono-Photography, and this subject must next be pursued.

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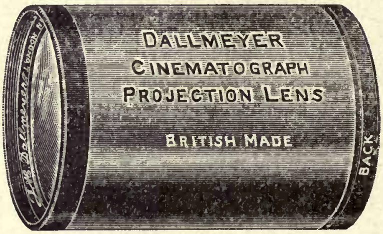

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CHAPTER III

CHRONO-PHOTOGRAPHY AND THE PRACTICAL DEVELOPMENT OF THE LIVING PICTURE

It has been repeatedly mentioned in the previous chapter that diagrams were unsatisfactory elements from which to build up the illusion of action, and the reason is not far to seek. The numerous attitudes through which a man or animal passes when in active motion are not perceived by the eye; they succeed one another so rapidly that only a general impression of the whole motion is conveyed to the mind; and this general impression, though perhaps satisfactory (from an artistic point of view) when shown in a single picture, cannot be expected to afford sufficient grounds for the preparation of an analytical series of diagrams representing the successive phases of a motion which is only perceived as a whole. It was early known that a moving object momentarily illuminated appeared to be motionless, and, in fact, this was easily deduced from the action of the Phenakistoscope. For instance, in 1850, Tyndall demonstrated the successive phases of a water-jet's motion by the expedient of illuminating it with an electric spark, and Fox-Talbot, in 1851, suggested the production of instantaneous photographs by lighting the object in the same manner. This portion of his patent he afterwards disclaimed, but it forms an appropriate starting-point from which to pursue the History of Chrono-photography, inasmuch as, in principle, it is a matter of indifference whether a momentary impression is made on a sensitive surface through the

illumination of the object for a very short period, or whether the permanently illuminated object is only permitted to throw its image on the plate for an equally limited space of time.

But, in its early days, the science of Photography did not provide its devotees with the means of securing an image in a sufficiently short time—a rapid exposure might be made, but no surface of adequate sensibility was available; so, though Photography was employed very early in the production of images for the Phenakistoscope, yet the only advantage secured was an accuracy of outline not to be obtained by hand. Plateau, in 1849, suggested the employment of photography for obtaining a series of pictures (preferably stereoscopic) which should be absolutely correct in outline, but he only foresaw a series of prepared *models* as the originals of his views; the length of exposure necessary excluded other ideas. This accuracy of outline, in some instances, was all that was required. When Desvignes, in 1860, obtained a series of views destined to show a steam-engine in action, the process was simple and the result certain. Each element of the engine necessarily followed a predetermined and invariable path, and consequently it was only requisite to place the engine in successive positions of one fly-wheel revolution in order to obtain a series of photographs which, when combined in the Zoëtrope, undoubtedly gave an accurate representation of the engine's usual motion. Still, it was in no sense a reconstruction of a previously existing action of the machine. The separate views were not obtained during the engine's motion, and their accuracy was due entirely to the certainty with which the object could be placed in a series of positions known on mechanical grounds to be those assumed by it when in action.

This certainty could not be secured when living creatures were the subjects, and they could only be posed in a series of attitudes such as, by supposition (generally

erroneous), they would assume in the course of the desired movement. Confirmation of this view is afforded by Mr. Wenham's letter of 1895, in which he relates an amusing story of a series of posed photographs obtained in 1852. The photographs themselves gave no cause for complaint, but when combined by means of the phenakistoscope the subject, who had been using a pestle and mortar, declared that "he never worked like *that!*" The first suggestion of Chrono-photography appears to be contained in Du Mont's patent of the year 1861. Therein he says: "Nowadays, photographers are enabled to reproduce on surfaces of great sensibility to the light what they have termed instantaneous images; they photograph a moving object, such as a running horse, etc., but have never thought of obtaining but a single image of the same object, and did not even wish to reproduce several successive ones, or the successive phases produced by motion." Several arrangements were suggested by him, in all of which a shutter was geared to expose the plates when they were perpendicular to the axis of the lens. The sensitive surfaces succeeded each other at regular intervals, being placed either on a prismatic drum, sliding frame, or dropped in series from an upper chamber into a lower one; the latter arrangement, according to the drawings, being almost identical with a very common method of plate-changing employed in later-day hand cameras. Ducos du Hauron filed a patent application in France in 1864 (No. 61,976) for "apparatus designed to reproduce by photography any scenes, with all the transformations undergone during a predetermined time." The specification was not published until 1900. The methods adopted are very interesting in the light of subsequent developments. In one of these a large number of very small lenses are used in conjunction with a long shutter band. Fig. 47 illustrates the principle of this method, showing the series of apertures, A,

and the band, B, which passes behind the lenses in passing from the roller C to the roller D. The band has a series of apertures so arranged that as the band passes behind the lenses each of the latter is exposed in turn, thereby obtaining a series of images. To project these images, a series of pictures so obtained, a series of similar projecting lenses are used, which are, however, adjustable, in order that each individual picture may be centred on the screen, and the pictures are successively

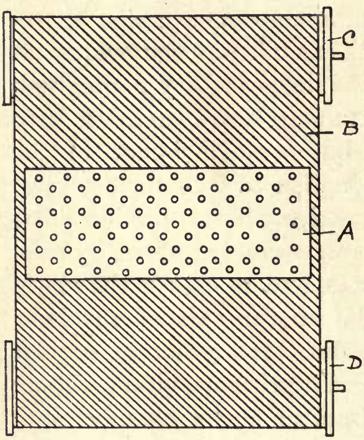

FIG. 47.

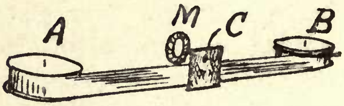

FIG. 47A.

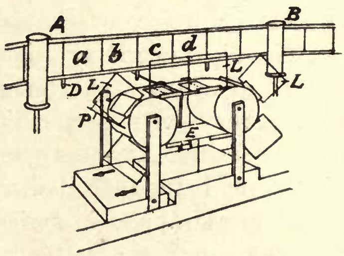

FIG. 47B.

projected by means of a similar shutter band. Other methods also are described for viewing the pictures. In one of these the successive images obtained on the plate are printed on a long band passing from one spool, A, Fig. 47A, to the take-up spool, B, and are viewed through a small view opening, C, by reflection from a concave mirror, M. In another method, illustrated in Fig. 47B, concave lenses are used in a similar way to that suggested by Maxwell in 1869 for the *Zoëtrope* (see p. 27). The positives are printed on a long band, AB,

which is drawn from one spool on to another, as in the method just described. A second endless band, E, carries a series of concave lenses, L, on the front edge, which pass with the film across a stationary viewing aperture. For this purpose the picture band carries pins, P, which engage projections, D, from the band, E, to draw the successive pictures, *a*, *b*, *c*, *d*, across the field of view in register with the lenses L. This method has a distinct similarity to some of the later continuously-moving film apparatus described in Chapter IV. Edwards also, in 1867, took out a patent in England (No. 849) for

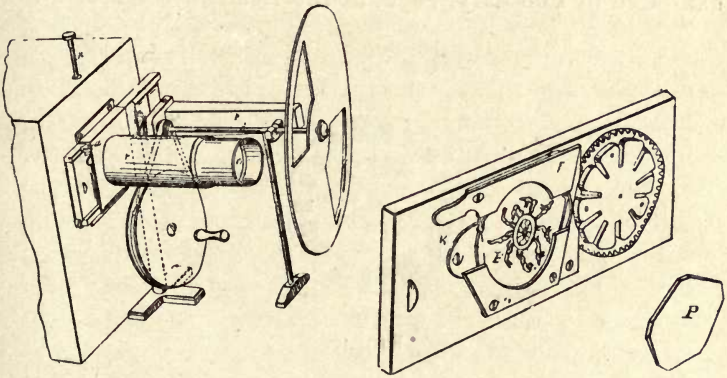

FIG. 48.

obtaining successive small pictures instantaneously on the same plate.

Two forms of apparatus, which appeared in 1869 and 1870 respectively, and casually quoted on p. 22, are interesting, inasmuch as the instrument intended for use with drawn designs shows a greater approximation to modern machines than does the one which employed photographs. Brown's apparatus, shown in Fig. 48, depended on non-photographic images, of which a series was painted on a polygonal glass plate, P, and dropped into a holder somewhat similar to a magic-lantern slide.

The gear-wheel shown served to rotate the designs, and was itself revolved intermittently by pins contained in the lantern, with which it engaged when the slide was pushed home. These two pins projected from a disc and engaged periodically with a star-wheel, formed in one piece with the gear-wheel which served to rotate the picture-disc—a motion which is, practically speaking, a Maltese-cross movement. A two-sector shutter was geared to eclipse the light when either of the two pins caused the design-wheel to move.

The second instrument, Mr. Heyl's *Phasmatrope*, was exhibited in February, 1870, at the Academy of Music in

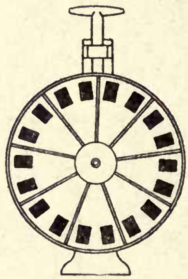

FIG. 49.

Philadelphia, and, though very successful, was based on the synthesis of poses, and not of analytical photographs secured from a moving figure. As shown in Fig. 49, the apparatus consisted of a large wheel containing nine divisions, each of which was furnished with two openings for the purpose of carrying transparencies. The whole disc could be revolved, step by step, by means of a ratchet and pawl worked by hand through a reciprocating bar. A shutter, operated by the same means, was so arranged as to cover the pictures during the whole period of substitution. The transparencies were prepared from posed subjects, such as the six different positions in a waltz, etc., the figures being ¾ inch in height and

projected to life size. The negatives were wet collodion, and that is sufficient reason why posing was necessary; putting the question of time required for exposure on one side, there still remained the difficulty of rapidly substituting a fresh sensitive surface for the one just exposed, and this difficulty could not be fully overcome until the introduction of dry plates, or, better still, films. But advances were nevertheless made, for the rise of chrono-photography afforded opportunity to work out mechanical details for obtaining rapid successive exposures, though the resulting views were not intended for subsequent recombination into motion.

It was in the same year (1870) that Marey commenced his researches on the analysis of motion, and the advance in sensibility of photo-surfaces has lent continual aid from that time onward. Marey in France and Muybridge in America soon entered into communication; the latter started work in 1872, their common object being the discovery of the successive attitudes which collectively make up a given motion, though they worked by somewhat different methods. Marey confined himself from the first to the method of casting his series of momentary exposures on one plate by means of one lens, while Muybridge adopted an opposed course. Some consideration is necessary as to the results involved by these modes of proceeding. Both methods had their respective advantages as regards Chrono-photography pure and simple, but one was limited in its development, the other contained the vital elements of the modern living-picture machine. Briefly stated, Muybridge's plan was to take successive views of an object as it passed in front of a series of cameras; Marey obtained a series of pictures by repeated exposures with one lens. Although Muybridge started work at a somewhat later date than Marey, he devoted greater attention to his subject, and it will be more convenient to first discuss his plan and all the battery

forms of apparatus because they have not successfully emerged from the "struggle for existence"—as regards the modern living picture they have died out.

In the year 1877 Muybridge, for the purpose of investigating animal motion, laid out a course, similar to a running-path, one side being bounded by a white background so as to obtain silhouette figures. Along the other side was ranged a series of cameras, the shutters of which were released by electro-magnets, set in action by the moving object itself by means of strings placed across the path, as seen in Fig. 50. This device allowed large pictures to be taken, every one representing the object as it appeared in front of the lens by which the photograph was secured; but it was absolutely necessary not only that

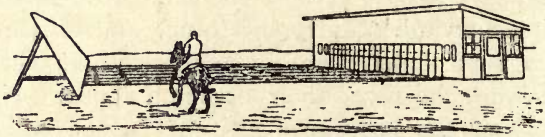

FIG. 50.

the members of the object should be in motion, but also that the object itself should move along the path.

Still, this method was adopted by Anschütz of Lissa, in Prussia, with magnificent results, and series of photographs so obtained by him met with a ready sale when printed on bands appropriately slotted for use as a Tachyscope (see p. 26). Much of his success was due to the employment of an improved form of shutter, very similar to the present focal-plane pattern with adjustable opening. Not only were his photographs prepared in this manner for inspection, but in the year 1889 he brought out his so-called *Electrical Tachyscope*, though there was no point of similarity between this instrument and the Tachyscope proper. As will be seen by the illustration (Fig. 51), transparent photographs were arranged in series round the margin of a disc contained in an inner room

and revolved before an opening equal in area to one design. Both the inner chamber and that containing the audience were darkened, and as each picture came behind the aperture a pin on the disc operated an electric current, thus causing a spirally wound Geissler tube (placed at the back of the picture) to light-up momentarily, the successive pictures being seen by the light of the repeated flashes. The disc-form of this apparatus was exhibited in 1889, but in 1892 it was patented with the additional suggestion

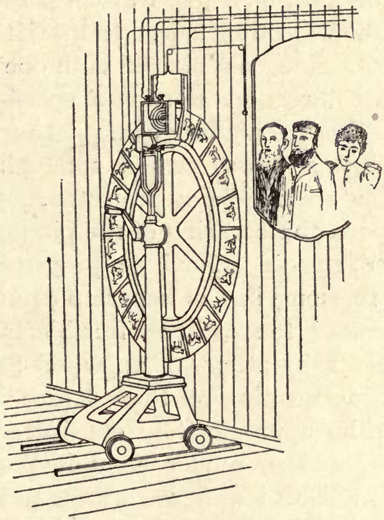

FIG. 51.

that a strip of photographs might be used, a suggestion put in practice shortly afterwards by the introduction of coin-freed or "penny-in-the-slot" apparatus (called the *Electric Wonder*) for viewing living pictures in this and other countries. This appears to have been the first practical and public development of Desvignes' suggestion, in 1860, to use an electric spark to render each picture "visible at its proper time and place." Nevertheless, it must not be forgotten that Donisthorpe, in 1876

and 1878, suggested his so-called *Kinesigraph*, the feature of which was intermittent illumination of a series of views in strip form by similar means to those just described, while the same expedient was one of the first adopted by Edison when conducting the experiments which resulted in the well-known Kinetoscope. About the same time Muybridge had perfected a projection apparatus, called the *Zoöpraxiscope*, which he exhibited at the Royal Institution in 1889. His silhouette pictures were placed round the margin of a 15-inch glass disc revolved between a condenser and projecting lens. Immediately in front of the glass disc a zinc one, pierced with one slot, revolved in an opposite direction at such a speed that the slot passed each time a picture came into position. The demonstration was very successful, some photographs not of silhouette nature also being projected.

But as regards the securing of the pictures themselves, the necessity of the object having a progressive movement as it passed the long line of separate cameras, as before explained, limited the choice of subjects greatly, and about the year 1887 attention appeared to be generally directed to concentrating all these lenses within a space which might be approximately considered as a single point of view, and so render possible the recording of successive attitudes of a figure which remained in one place; the background therefore no longer needing to be an absolutely plain surface as was the case when successive attitudes were photographed with a change of local position. Le Prince, working on this principle, in 1888 approached the modern type very closely in appearance, but in appearance only. As will be seen from Fig. 52, he employed a battery of sixteen lenses acting on two sensitive bands, wound from one pair of rollers to another, the two films being side by side. The eight lenses facing one film were released in rapid succession, somewhat overlapping in point of time; the other

series of eight lenses were then discharged, during which time the first film was moved on ready to receive another eight pictures; each film being clamped by a cam-actuated frame during exposure. These exposures were made overlapping in point of time; that is to say, one lens was always opened before the preceding one was shut off, and when used for projection, as in Fig. 53, this same principle was followed, and therefore no period of darkness occurred between the respective separate pictures. The complicated nature of the shutter mechanism is shown in Fig. 54, the individual shutters being set in action by partially

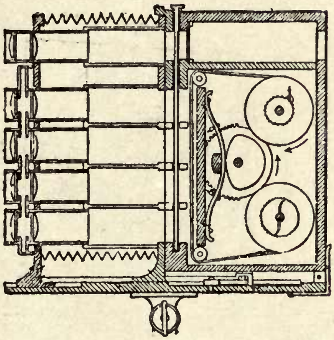

FIG. 52.

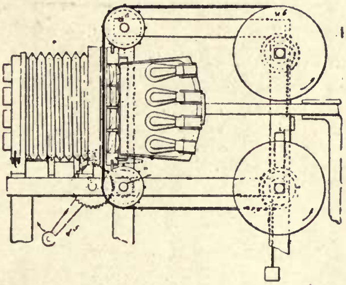

FIG. 53.

toothed wheels, rotated in common, but acting at different times by reason of the varying position of their teeth. At the first glance this combination of serial exposure, intermittently moving film, and clamping-frame appears to be the first machine of the modern type. But consideration will show that Le Prince's apparatus was founded on absolutely different principles to those in vogue at the present time, although some resemblance may be seen to types suggested later, and it may be that future machines may follow some of this inventor's devices. The modern apparatus takes a series of pictures, by means of one lens (or at least from one point of view),

on one film moved between the exposures. Le Prince used many lenses and moved his film during the time that neither it nor the lenses facing it were in use, although exposure was going on by means of other lenses on another film. Practically, his apparatus was a duplicate arrangement of the battery type, and, further, the great difference in position between the lenses at opposed corners must have given rise to varying aspects of foreground objects, thus inducing a false motion of the same on the screen.

Londe meanwhile had entered the field. He had, in conjunction with Colonel (later General) Sébert, con-

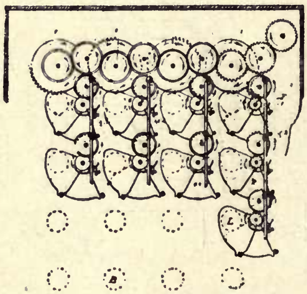

FIG. 54.

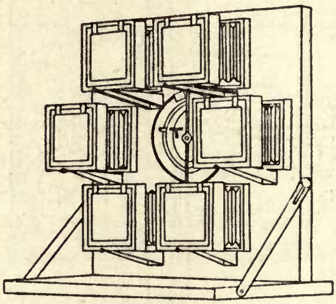

FIG. 55.

structed a compound apparatus composed of six independent cameras arranged in circle as shown in Fig. 55. The six lenses of these cameras were furnished with a series of shutters, naturally arranged in circle, and each composed of two members. The motive power was supplied by springs (S, Fig. 56), and each shutter had two projecting catches, C, one of which is shown in the drawing, the other being situated underneath. A centre disc, T, rotated when released, and was furnished with two projecting stops, one of which opened the shutter by pressure on the catch C, while the other closed it. The latter stop P was adjustable for the purpose of varying the exposure by increasing the

distance between the two stops. This apparatus was used by Colonel Sébert for the study of projectile motion.

One development of the battery type for securing a limited series of views is that employed at the Salpêtrière for the analysis of abnormal motions, such as epileptic fits, St. Vitus' dance, etc. Twelve lenses are employed, and the shutters released by electro-magnets (Fig. 57). The great point of the apparatus is an electrical controller, by which the period allowed to elapse between two exposures is capable of regulation within wide limits. The series of twelve views can thus be completed in $1\frac{1}{5}$ seconds or ex-

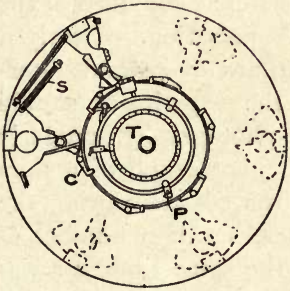

FIG. 56.

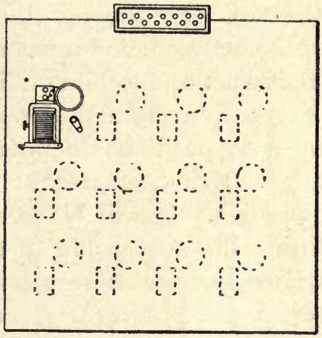

FIG. 57.

tended over minutes. This apparatus was three years later in date than the pioneer film machine by Greene and Evans, similar in character to those of the present day, which have in nearly all instances followed its arrangement, in general principles, at least, though the form has been simplified and improved.

The multiple-type having shown itself as adapted solely to the purposes of Chrono-photography, and being without capability of adaptation in the direction of obtaining long series, there remains simply the description of the single-lens system of Chrono-photography. This method, instituted by Marey, was represented in its first stages solely

by instruments devoted to the analysis of motion; by slow stages and gradual improvement it developed the modern living picture apparatus as we now know it. The earliest attempt in Chrono-photography was hardly worthy of the name, yet it pointed the road to the true method of single-lens working. In the year 1865 Messrs. Onimus and Martin exposed the bared heart of a living animal before an opened lens for the purpose of photographing it while in motion. With the low degree of sensibility then obtaining among photo-surfaces the exposure naturally extended over one or more pulsations of the heart, but as a pause takes place at each extreme of the heart's beat, the outlines of these positions were better defined than the space between, and a record was therefore obtained of the maximum and minimum limits of a pulsation. Clearly it was only necessary to secure outlines of several intermediate positions in order that the experiment should attain the character of Chrono-photography, properly so called. It will be seen that a photograph of a man lifting his arm would (if the exposure lasted during the whole movement) result in a blur, but if a number of separate exposures were made in the same time, a series of overlapping images, equal in number to the exposures, would occupy the place of the one-exposure blur, and the outlines of these images would in addition form a perfect record of the successive positions of the arm.

The apparatus necessary for this species of Chrono-photography (*i.e.*, on a fixed plate) is simple in the extreme. It is only required that a slotted shutter should be revolved before the plate (Fig. 58) in order that successive images may be formed; and these images will be separated in proportion to the movement of the object. This method is all-sufficient for the *analysis* of motion, but the results had anything but a popular aspect; the different images frequently consist in nothing but lines and dots representing rods and beads attached to a black-robed subject,

who when fully equipped appears to be under the hands of a surgeon rather than those of a photographer. Much work has been done on these lines, but such pictures, valuable as they are for the physiological information they impart, are in no sense suited for the reconstitution of the movement of which they form the elements, and much time elapsed before attempts were made to secure separate and distinct photographs of the phases of a given motion. Had a flexible surface been available, no doubt progress would soon have been made; indeed, the necessity of separating the images was felt, and a longer plate, shifting between each exposure, employed. Another method of separating the images was to interpose a revolving mirror

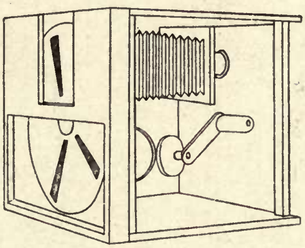

FIG. 58.

between lens and object. This arrangement is interesting from the fact that it was subsequently suggested to use the same device in a reverse manner, causing it to project separated pictures on to one place on the screen, while the original arrangement gave separated pictures on the plate from an original which remained in one place.

It cannot be postulated too emphatically that, even at this early date, nothing was required but a flexible and transparent film, capable of receiving an emulsion of increased sensitiveness, in order that the modern living picture might spring into existence; but twenty years were fated to elapse before these necessities were placed at the disposal of the photographic world. Therefore nothing

was available except glass plates, and these were naturally used in circular form in order that as long a series as possible might be secured.

In the year 1874, however, an opportunity occurred of photographing a very brilliantly lit object of great interest; and a desire on the part of M. Janssen to obtain a chronographic photo-record of the Transit of Venus across the sun's disc caused him to invent his *Photographic Revolver,* and successfully employed it in the far-off regions of Japan. This instrument was placed under cover, as shown in Fig. 59, and when in use was directed on a heliostat, which served to keep the image stationary by

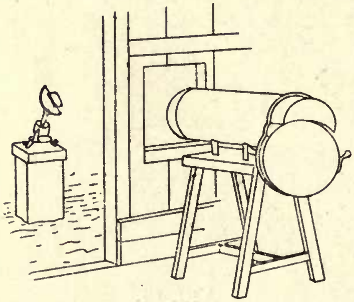

FIG. 59.

neutralizing the sun's apparent motion. With it forty-eight images were taken around the edge of a circular plate in the space of seventy-two seconds, and this operation was repeated four times, so as to secure a record of the interior and exterior contact at each margin of the sun's disc. The mechanism by which this was effected (shown in Figs. 60 and 61) merits description as being the first practical automatic apparatus for obtaining a chronophotographic record consisting of separate pictures. A large wheel, R, carried the sensitive plate (making one revolution in seventy-two seconds), and in front of it a disc, B, pierced with twelve openings, made one revolution

in eighteen seconds. Between these two wheels was placed a partition, S, pierced with a single opening. When the mechanism was released, the motor-wheels, O, set both the sensitive plate and shutter-disc in motion. The sensitive plate made the forty-eighth part of a revolution and then stopped, this being effected by a Maltese-cross movement. At the moment of its arrest one of the twelve openings in B passed the fixed aperture P, thus making an exposure. The plate moved on, while protected by the opaque part of B between two openings,

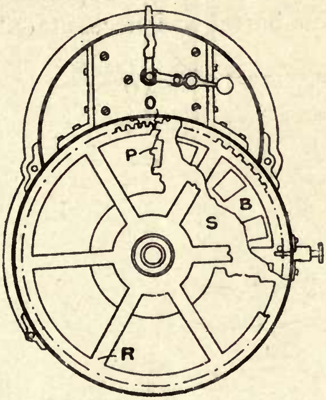

FIG. 60.

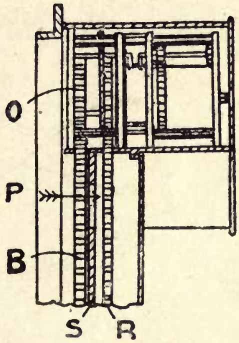

FIG. 61.

and then stopped for the next exposure. Some instruments of this kind were taken by an English commission to the Andaman Islands in the following year (1875) for the purpose of observing an eclipse of the sun, but the expedition was unsuccessful owing to adverse weather.

Still at best the Photographic Revolver was but an observing instrument, and little could be done in the way of combining the distinct views into one motion; forty-eight separate pictures at the rate of twelve per second would only last the fifteenth part of a minute, and even then would compress the events of seventy-

two seconds into that time. To obtain a longer series, Donisthorpe in 1876 further developed Du Mont's idea of rapidly dropping an exposed plate into a lower chamber, so leaving the next free for exposure, and provided a special gearing by which the shutter covered the lens during the change. Nevertheless, Janssen's instrument was the model on which Marey founded his *Photographic Gun*, which was of real value for analyzing motion in such a way that it could be subsequently re-compounded by means of the *Zoëtrope*. Its name was well chosen, and is perfectly descriptive of the apparatus shown in Fig. 62. The length of barrel was necessitated

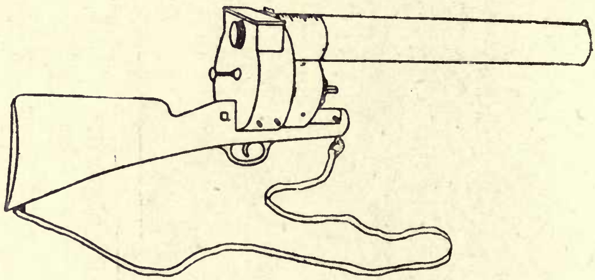

FIG. 62.

by the use of a long-focus lens, which was, of course, absolutely indispensable when photographing a small object at a considerable distance. This barrel was arranged so as to telescope for focussing purposes. The breech contained clockwork mechanism for effecting the series of exposures, and a glance at Fig. 63 will explain the methods employed. It will be understood that the back cover is removed in order to show the parts. On pressing the trigger a circular shutter with one opening commenced revolving at a predetermined rate. Behind this a disc (half of which is shown in the drawing) with twelve openings also revolved, the sensitized plate lying

behind it and rotating with it by friction. This disc together with the sensitized surface, was rotated by means of a pawl (shown at the bottom left-hand) on an arm worked by an eccentric, and every time one of the twelve openings, backed by a portion of the sensitized plate, came to rest opposite the lens-aperture the hole in the shutter passed in front of it, admitting light and making an exposure. It will be understood that during its movement the sensitized plate was protected by the opaque part of the revolving shutter. Marey used this instrument in order to obtain some extremely effective

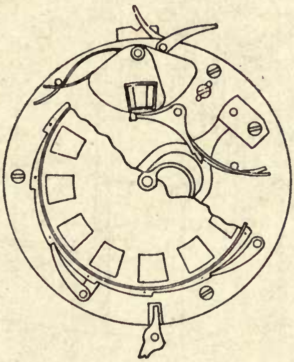

FIG. 63.

photographs of birds in flight; nevertheless, the apparatus was far from perfect. The defect of this instrument was that twelve images in very few cases gave a complete cycle of movement; when the last picture of the set (say of a bird in flight) was reached, the bird had not arrived at that stage when the wings occupied nearly the same position as in the first picture. But still Marey adhered to the plan of using *one* lens for making successive exposures, and his later improvements followed out that principle.

In 1892 Demeny showed a similar but much improved apparatus at the International Exhibition of Photog-

raphy. This was of the usual disc form, a rotating shutter being used the travel of which was far more rapid than that of the sensitized plate; the latter only moving a short distance to its next position while the opaque part of the shutter made nearly a revolution before the single aperture passed the lens. This apparatus was called the *Photophone*, and its construction will be understood from the very similar projecting apparatus, Fig. 64, named the *Phonoscope*, in which the major portion of the shutter is cut away in order to show the picture-disc.

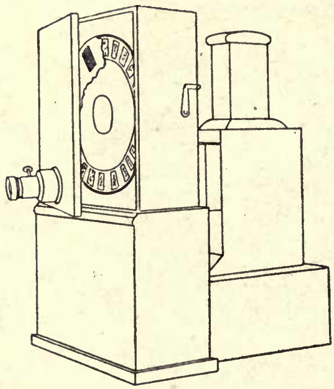

FIG. 64.

The origin of this name is found in the fact that M. Demeny used this instrument for securing a series of twenty-four photographs of a man during the act of pronouncing some phrase, in order to analyze the lip-motions. The reconstitution of the lip-action was so successful that a deaf-mute was enabled to read the words "Vive la France" from the lips of a photograph. The set of pictures being sufficiently long to cover the whole period of utterance, an enthusiastic deaf-mute could pass the day experiencing (it is impossible to say "hearing") the above-mentioned patriotic sentiment. It is worthy

of notice that even the intelligent specimen of humanity above referred to was absolutely nonplussed when the handle was turned backward, and the lip-motion consequently reversed. Demeny's specification in which the Photophone is described also includes some modifications directed towards obtaining longer series. The views were mounted in spiral on a non-transparent drum, the axis of the latter being furnished with a helix which traversed the drum at such a rate as to maintain the spiral set of pictures under the inspection lens, as seen in Fig. 65. The shutter was not interposed between eye

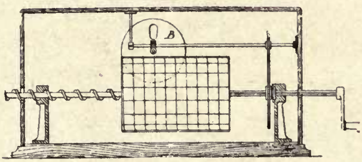

FIG. 65.

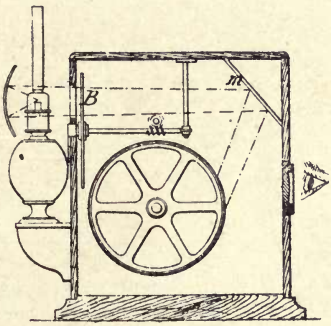

FIG. 66.

and picture as is usually the case, but was mounted between light and drum. Fig. 66 shows the beam of light passing through the slot in the shutter B, and, after undergoing a deviation by the mirror *m*, falling on the drum and thus illuminating the successive pictures by intermittent flashes as the slot in the shutter periodically permits light to pass. A reference to Fig. 11 will demonstrate the relation between Lommel's invention of 1881 and that of Demeny in 1892; the principle being the same although the latter apparatus gave a longer series and displayed but one image at a time. The specification suggests that a phonograph might be combined

with the inspection apparatus—an idea previously set forth by Donisthorpe in 1876 and 1878.

During these later years the extreme rapidity attained by photographic emulsions, together with the possibility of obtaining long lengths of flexible transparent film, rendered the production of a long series of photographs in rapid succession possible. Many steps leading up to this desirable consummation have been quoted in the past pages, and methods of securing rapid exposures were invented to keep pace with increasing speed of plates; indeed, it may be said that as a general rule it has always been possible to procure a shutter so rapid in its action

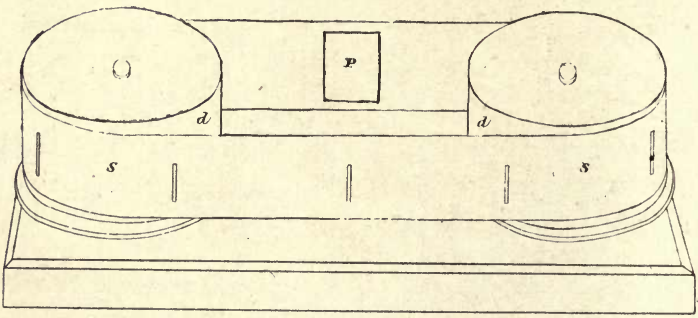

FIG. 67.

that it refused to yield a picture, and shutter devices have always been ahead rather than abreast of plate speeds.

The idea of using a band for the purpose of lengthening the series of views is almost as ancient as the Phenakistoscope itself. In fact, the first published description of the Stroboscope contains a suggestion of this character, Stampfer therein intimating that a long endless band might be passed over two rollers, provided that suitable means were employed in order to interrupt the light at correct intervals of time. And, indeed, this fact was never lost sight of. Desvignes, in 1860, proposed to place his Zoëtropic designs on endless bands (Fig. 67), but in the

days of wet-plate photography such an expedient was entirely out of the question so far as *securing* pictures was concerned, and even the early dry-plate, with all the assistance it rendered, lent no substantial aid in this direction. Thus, in 1876, Donisthorpe proposed to place his Kinesigraph pictures on a band arranged to run off one roller on to another, but only for purposes of inspection; the negatives from which they were printed were obliged to be obtained at a comparatively low speed on plates and the positives actually mounted at accurate intervals. Not until the introduction of celluloid as substitute for glass was it possible to secure a long series of exposures on

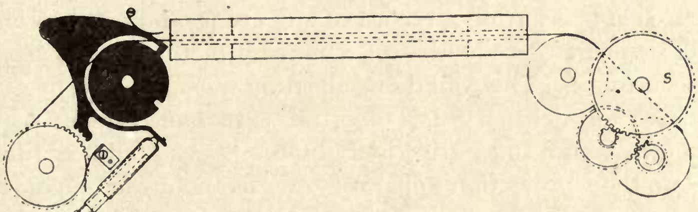
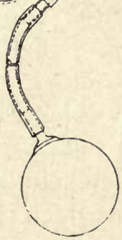

FIG. 68.

a suitable strip, and the commercial existence of this eminently suitable support began to bear fruit in the year 1888. Here, as in every other branch of our subject, the first steps were not directed towards the production of a living picture. Potter suggested a very simple arrangement for reeling a series of transparencies on a transparent band through a magic-lantern, and a few months later Adams patented an arrangement for the same purpose, which is interesting from the fact that it contains, in a crude form, very similar features to the first workable living-picture machine. As seen in Fig. 68, the band was drawn onward by a spring roller (S), but was normally prevented from moving because it was gripped between a

roller and brake-block, both shown black in the illustration. When a pusher came into action the brake-block was raised, as shown in the drawing, until the stud dropped into a slot in the roller, when the teeth also locked the wheel attached to the spool. This arrangement would certainly have been unsuitable for rapid working, if only on account of strain on the film, but it is interesting as an example of how an idea may be "in the air," for this spring roller, allowed to act intermittently by means of an escapement tooth, was the feature of the apparatus patented in the next year by Messrs. W. Friese-Greene and M. Evans, to whom must be adjudged the honour of having first introduced a practical instrument capable of securing a record of any event, and suitable for subsequent reproduction of a moving picture of the past occurrence. Their joint specification was filed on June 21, 1889; on February 25, 1890, an actual instrument was shown before the Bath Photographic Society, and at that date their projection apparatus was in the maker's hands. Their camera was capable of securing three hundred exposures at the rate of ten in each second, though this speed could be increased considerably if required. The construction of this piece of apparatus was most ingenious, and so simple that a short description will suffice. The film passed from one spool over a plate, which held it flat for exposure, and then on to a second spool by which it was wound and stored. Both spools were driven at an equal speed from the main-shaft, and thus the film would have passed the exposure opening with a steady and uniform motion had it not been that a roller was interposed between the light-aperture and the receiving spool. This roller contained a spring, continually wound from the main-shaft. The spring would have forced the roller round as fast as it was wound up but that on the roller's edge was placed an escapement tooth which rested against a cam. This cam (itself in continual rotation) stopped the

roller from turning, but a gap in its edge allowed the escapement tooth to pass once in a revolution. When this occurred the roller made one turn and drew down sufficient film to remove the exposed picture and substitute the next portion of the film. While this was stationary and the cam making its next revolution, the winding-up bobbin was storing away the piece of film just pulled down, while the feeding-spool was reeling-off just sufficient to supply the next sudden revolution of the spring roller, the spring of which was at the same time being wound up. A special shutter was also shown, but it was of comparatively little importance when compared with the arrangement for intermittent film-feeding described above.

Greene was also working about this time, apparently in conjunction with Rudge, on a machine designed to project successive pictures without interrupting the light. The images were placed alternately on the edges of two discs which revolved side by side in front of a single large condenser. The light and condenser could be moved slightly out of the central line so as to illuminate, say, the left-hand picture, and were then shifted so as to light up the next design situated on the right-hand disc. While this was being shown the left-hand disc turned one stage in order to bring the third picture in position. Separate projection lenses were used, one facing each disc. The extent of movement required by the condenser in order to illuminate the images alternately was very small, and furthermore the light was not suddenly cut off, but died away gradually, thus reducing the flicker. An experimental machine on these principles was shown before the Bath Photographic Society, but there appears to be no record as to any exhibition of the perfected instrument.

As before stated, the honour of prior publicity undoubtedly rests with Messrs. Greene and Evans, but others were working at the same problem, and in August, 1889,

Messrs. Donisthorpe and Crofts filed a specification in which they showed another means for securing a stationary film during the period of exposure or projection. This device was ingenious, the film being in continual process of unrolling from one spool and rolling on the other, and yet the portion in use was kept stationary opposite the lens without any sudden pull to change the portion exposed. The film passed from one spool to another at a continuous speed past the exposure opening, but this movement was periodically neutralized by lifting film, rollers and all, at a speed equal to the downward motion of the film by means of a crank-motion, the whole frame being steadied by rollers (shown black on drawing) running between guides (Fig. 69). Thus a portion of film opposite the lens was continually travelling nearer to the bottom roller, but was also being raised at an equal speed; the same piece of film therefore remained in the same place during exposure. This terminated, the whole frame sank to a sufficient extent to expose the next section of film, which, though still moving on, was kept in the same position for so long as necessary by a repetition of the raising of the whole mechanism. Though this apparatus is somewhat complicated, the description afforded by the specification is specially interesting as showing the difficulties to be contended with at that date. The inventors proposed obtaining their negatives on strips of sensitized paper. Now paper, even at the present day, imparts some grain to the negative, and this was the case to a greater degree nine years ago. The pictures, therefore, were designed to be prepared on a larger scale than at present—two and a half inches diameter was suggested; while for the band of transparencies the only available material was again paper, rendered partially transparent by vaseline or castor oil. This difficulty was so great that the inventors also suggested that an opaque band might be used and the pictures projected by reflected instead of

transmitted light, somewhat on the principle of the Aphengescope, and a method quite recently revived. The large size of the pictures, and consequent large extent of film required to pass in a given time, together with the considerable mass of moving parts, must greatly have hampered the inventors in preparing an effective machine;

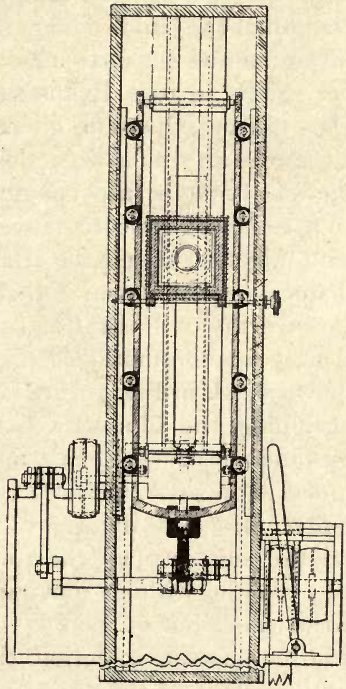

FIG. 69.

but, after all, difficulties and even failures, to the philosophic mind, are of almost equal interest with conspicuous successes; they afford equal ground for consideration, and furnish data from which to accurately estimate the relative values of various systems.

This apparatus again points out the one essential needed to complete the modern living picture—a trans-

parent, structureless support. This necessity was furnished in the year 1888 by the introduction of celluloid. On its first appearance this material was not so satisfactory for photographic purposes as it is now, neither could it, at first, be obtained in the requisite ribbon form, and Marey's first instruments for using films were rendered ineffective (except as regards pure chrono-photography) by the limited length of the bands commercially available. Nevertheless, invention and suggestion now began to move at a rapid pace. Early in 1890 Evans suggested several arrangements for moving the film intermittently. The principal form was one in which a friction-roller in continuous rotation was brought into contact with the film periodically for a sufficient time to move it one picture length. This end might, of course, be attained by the use of many mechanical equivalents. Other arrangements shown by him are worthy of illustration as embodying the germs of some more modern motions. For instance, two small rollers, shown black in Fig. 70, are kept in continual rotation, and gripping the film between them, draw it onward at a constant speed. But the arm on which these rollers are mounted is drawn backwards and forwards by the black eccentric seen on the right. Consequently, during the time the lens is open the rollers are drawn to the right along the film without moving it though they are rotating all the time; but so soon as the lens is closed the arm moves in the opposite direction, thus drawing the film onward to the extent of the travel of the arm, plus the amount due to the rotating grip of the rollers. Another arrangement has two rollers situated on the ends of a rocking arm mounted on a pivot (A, Figs. 71 and 72). This arm is periodically tilted by a lever worked by the black cam seen at the bottom of the drawings. In Fig. 71 an exposure has just commenced. The film is held steady by a light gripping frame, and the store reel is occupied in rolling-up the slack portion of film. When

this is accomplished the cam causes the rocking-arm to tilt, as seen in Fig. 72, thus drawing a fresh portion of film in front of the lens, and then, suddenly returning to its first position, leaves a double loop of slack to be stored away exactly as seen in the preceding figure. A few days afterward Varley filed a specification, showing another means for attaining the same end as that secured by Evans's rocking-arm—namely, causing a loop to be formed

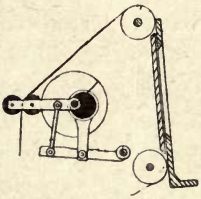

FIG. 70.

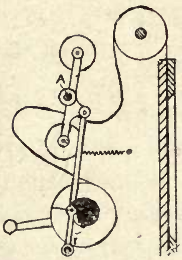

FIG. 71.

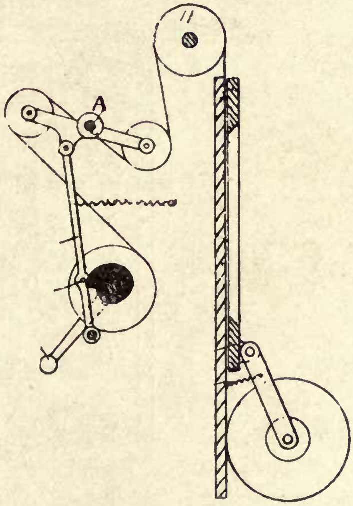

FIG. 72.

in the film by means of intermittent pressure. The film was steadied by the action of two spring-pawls, which gripped it against two rollers (A, Fig. 73). By the revolution of a cam, not shown, an arm, B, was periodically thrown forward against the film, of which a sufficiency was driven back between the two rollers, A, to draw an exact picture-length down. The arm then returned to its first position, while the store-reel took up the slack so

formed. The cam seen in front works a double shutter by means of levers. It was also suggested that light should be allowed to act through four holes in a screen, forming marks at the sides of each picture for the purpose of punching holes in exact register.

M. Marey, towards the end of 1890, constructed a chrono-photographic camera in which a band passing from one spool to another was employed. This apparatus had been gradually evolved from one constructed in the year 1888, having a *paper* negative band periodically

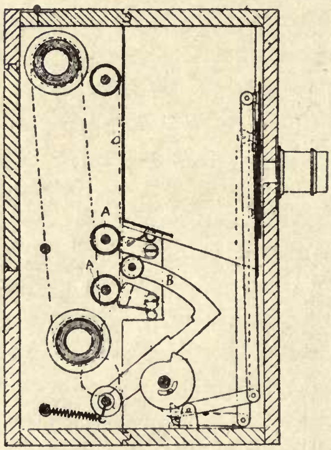

FIG. 73.

arrested by an electro-magnetic grip. In 1889 the paper gave place to film, and a zoëtropic instrument combining views so obtained was exhibited at the Paris Exhibition of that year, when M. Marey showed the apparatus to Mr. Edison. In 1890 the mechanical details were finally arranged as shown in Fig. 74. The *Chronophotographe*, or, as it was first called, the *Photochronographe*, was driven by clockwork, and all its parts could (previously to making an exposure) be set in motion without actuating the film. On touching a stud a friction-roller pressed the film

against the top right-hand roller (already in motion as stated), which then began to drag the film off the left-hand bobbin, past the exposure opening, and past a spring, as shown by the dotted line. The receiving-bobbin was mounted on a revolving spindle, but could not itself revolve, by reason of the pressure exerted on it by a brake. So soon, however, as the stud pressed the friction-roller against first-mentioned roller, this brake was taken off, and the receiving-bobbin, being free to revolve, took up the film passed on to it. To render the film periodically stationary, a rounded bar was pressed against it at proper intervals of time by means of a star-cam, thus gripping it tightly and preventing its motion. Inasmuch, however, as the motive-roller was continually dragging at the film, the latter would have been torn

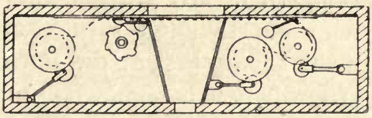

FIG. 74.

were it not that the film passed over a weak spring. This straightened out under the pressure exerted by the film, thus shortening its path and feeding the roller with sufficient film to last until the grip was taken off, when the spring returned to its former position, and assisted to draw the next section in front of the exposing aperture. M. Marey did not succeed in obtaining very long series of exposures with this apparatus. About forty pictures were taken in whatever period of time seemed desirable, and he complained, in an account given by him of his work, that bands of film longer than 4 metres were not obtainable. Still, had he confined his pictures to moderate dimensions, he would doubtless have been more successful from the living-picture point of view; the fact of procuring negatives 9 centimetres (about $3\frac{1}{2}$ inches) square was quite

sufficient to fill up his band long before an extensive series was obtained. But as Director of the Physiological Station his work lay mainly in the analysis of motion, and the only use made of his early serial pictures was to recombine a phase of motion by means of a modified Zoëtrope in order that the real action of one second might be spread out in point of time to facilitate leisurely inspection, and for this purpose it was necessary to remount the positives at proper intervals, the spacing on the negative band being slightly irregular. About the same time M. Marey constructed a somewhat similar instrument for use with the microscope, in order to record the various motions of the lower forms of animal life.

At this point it is difficult to say whether a retrospective view is necessary or not. If first ideas are to be taken into consideration, then Mr. Edison should have been mentioned earlier; but the first intimation of his work in the domain of the Living Picture did not reach England until May 28, 1891, when a somewhat meagre account of his *Kinetoscope* was printed in *The Times*, having been received through Dalziel's Agency, while the full description of his invention, filed in the United States, August 24, 1891, was not issued until March 14, 1893 (No. 493,426), and was never patented in England. The first public exhibition of this instrument seems to have taken place at the Brooklyn Institute on May 9th, 1893, the first machines in England being shown in Oxford Street in October, 1894. It certainly appears as though Edison might have established a claim to be considered the father of the modern Living Picture (so many forefathers have been mentioned; it is difficult to trace the exact pedigree) had he not been deluded and delayed by affection for his pet child, the Phonograph. It was apparently in 1887 that he first conceived the idea of coupling the reproduction of a past event with the repetition of sounds recorded at the same time. He appears to have spent much time in

a fruitless attempt to secure his negatives in a manner analogous to the reproduction of speech on the phonograph—that is to say, in a spiral line round a cylinder similar in every respect to that of the sound-recording instrument, which was put into action at the same time. And here it may be well to explain the nomenclature of Mr. Edison's various productions. A *Kinetograph* takes the separate pictures, the *Kinetoscope* recombines them into motion. The prefix of Phono- denotes that a Phonograph is coupled with the instrument, consequently a *Phono-kinetograph* records both events and sounds, and the *Phono-kinetoscope* reproduces them by direct vision. This instrument has also been called the *Kinetophone.* Edison's first pictures were absolutely microscopic, a matter which at once gave rise to a dilemma. If small, they needed considerable enlargement in order to be viewed, and this necessitated a sensitive surface, which should be practically structureless. Nothing but collodion would meet this requirement, and its low degree of sensitiveness to light rendered it very difficult to obtain an image at all. Increase of aperture in the lenses certainly would meet the difficulty, but only at the expense of that definition which was so essential when subsequent enlargement was required. Therefore this method was abandoned, and larger negatives obtained in spiral on sheets of celluloid wrapped round a cylinder or on the edge of a disc, and at this stage Edison adopted the method of lighting his views momentarily for inspection by means of a Geissler tube, through which a current was passed every time pins (placed on the revolving disc) made the necessary contact. This was the plan adopted in Anschütz's Electrical Tachyscope, exhibited in 1889; but it is apparently impossible to discover at what date Mr. Edison hit upon the same device. He finally settled down to a form of instrument having a one-slot shutter and continuously moving band; the exposure was consequently extremely

brief, and the waste of light involved by this arrangement rendered his apparatus as crude in its principles as the first Phenakistoscope, though from the point of view of mechanical accuracy it was a marvel.

In many of its mechanical details, however, Mr. Edison's perfected Kinetoscope was unique, and a short description of the apparatus, considered as a whole, will serve as a basis for their elucidation. The mechanism was contained in a cabinet furnished with an inspection opening at the top, as seen in Fig. 75. This cabinet was divided into

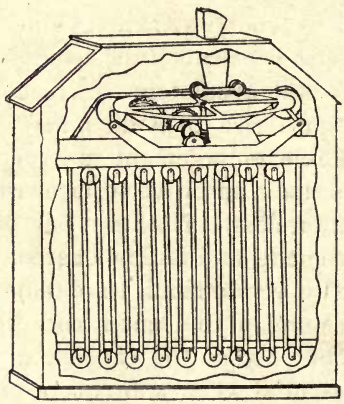

FIG. 75.

three compartments, the one above extending over the whole width of the case, and containing the essential mechanism, the other two divisions each occupying one-half of the lower portion. One side, shown in the drawing, contained a spool-bank accommodating an endless film; while the other side enclosed the motive mechanism, which was naturally electric, that method of driving being well known as Mr. Edison's favourite. The celluloid band was of the now familiar form; that is to say, each margin was perforated with four holes to every picture, though in 1890, when his pictures were smaller, Mr.

Edison used a single line of perforations only. This endless perforated band passed from one side of the spool-bank to the other through the upper chamber, being stretched over two sprocket-wheels (fitting the perforations), which drove the band past the inspection lens at a constant speed equal to forty-six pictures per second. Below the band, and opposite the inspection opening, an incandescent lamp was situated; the American patent shows a peculiar form of alum-trough placed between lens and film in order to absorb heat, and also a prism

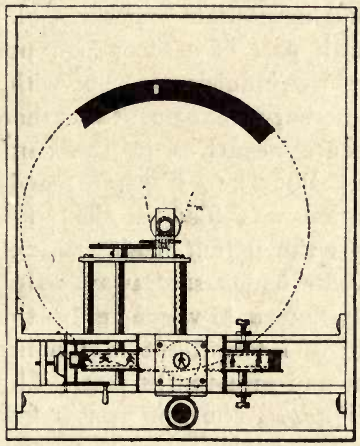

FIG. 76.

arrangement for altering line of sight. As the band was not arrested for the inspection of each picture, some means of providing momentary illumination was necessary, and this was accomplished by a one-slot shutter making forty-six revolutions per second, so as to allow light to pass each time a picture was accurately centred. The mechanical ingenuity displayed in the accomplishment of this method of intermittently illuminating a film continuously moving at so high a speed is worthy of all praise; but it must not be overlooked that the *system*

itself was faulty, and totally precluded use of the apparatus for projection purposes. A glance at Fig. 76, which shows the shutter and film in plan, will demonstrate the enormous waste of light involved by Mr. Edison's arrangement. The slot was only one degree in width, and therefore only one-three-hundred-and-sixtieth part of the available light was allowed to pass to the eye. Under these circumstances no known source of light would have been powerful enough to stand the waste in projection work, while a camera arranged on the same principle would have been an impossibility; an attempt to secure forty-six pictures per second would necessitate exposures of less than the sixteen-thousandth part of a second—a period too brief for the most sensitive emulsion to cope with.

An entirely different arrangement was therefore adopted in order to secure negatives in the camera, but little information was allowed to transpire; and although the patent specification was filed in the United States on August 24, 1891, the patent itself was not issued until more than six years had passed away. Up to August 31, 1897, it was only known, in vague terms, that Mr. Edison used some form of intermittent mechanism giving one-tenth movement and nine-tenths rest. The arrangement is shown in Fig. 77. The film passes from spool A to spool B, being drawn along by a sprocket-wheel driven from the pulley C. The film would move continuously were it not that the rotation of the sprocket-wheel is periodically checked by the interaction of two-toothed wheels, one (D) situated on the main shaft, and the other (shown black in the illustration) beneath the sprocket-wheel and on the same axle. To save strain, the pulley runs loose when the two wheels D, E are locked together, as shown in Fig 78. The right-hand wheel is just about to allow the other to move one stage, the tooth passing through a slot (Fig. 79). So soon as this tooth makes its escape the wheel E turns and carries with it the sprocket-

wheel, and therefore the band. When a picture-length has passed, the next tooth on E strikes the surface of D, and remains locked until the next slot comes round and permits another tooth to escape.

This machine would not, perhaps, be of great importance were it a recent invention, but it must be remembered that it was filed in 1891, on the same date as the Kinetoscope specification, and these two documents make mutual cross references to one another. The invention not having been patented on this side of the Atlantic, the question hardly affects the English public; but if rumour

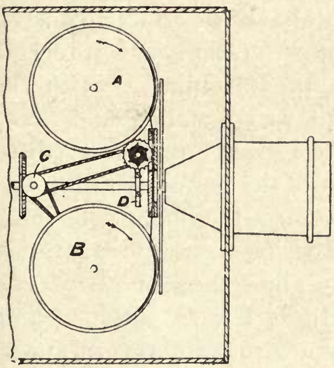

FIG. 77.

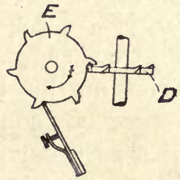

FIG. 78.

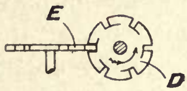

FIG. 79.

speak truly, there were many users of perforated film in the States who naturally did not foresee that, years after acquiring their machines, they would have a covering patent flourished in their faces—a patent concealed from public view for six years!

Two projecting machines were at one time on the market under Mr. Edison's name; but they will be referred to later, neither of them seeming to employ the intermittent motion of an escapement nature which Mr. Edison undoubtedly patented in 1891 and presumably applied to his camera. It, however, seems feasible that this patented

method was abandoned in favour of another; the wear must have been great, for both wheels were subjected to sudden impact forty-six times per second, and the interval between these impacts was mainly occupied by frictional contact between tooth and checking surface.

From what has been said respecting the Kinetoscope, it will be seen that this instrument was practically identical in principle with Anschütz's Electrical Wonder exhibited at Frankfort in 1891, with the difference that in order to secure momentary illumination of a continuously moving film Edison used a revolving shutter and Anschütz a flashing Geissler tube; Edison's line of sight was vertical, and that of Anschütz horizontal. Furthermore, in 1888, Le Prince suggested the use of perforations and sprockets for feeding his band through the machine; but in the absence of celluloid this band was metallic, and acted rather as a carrier. Still, Mr. Edison must be credited with the practical introduction of the perforated film, and this system of perforation formed the foundation of a large number of methods for securing accurate registration and intermittent movement. The gauge of perforation which he instituted has, with a few exceptions, been practically adopted as the standard, and the maker of every machine in present use which utilizes perforations for feeding is so far indebted to the "Wizard of the West." Furthermore, though the Kinetoscope was only available (publicly, at least), for inspection, and not for projection, Mr. Edison did the world a great service in bringing the matter of living pictures into a prominent position; he demonstrated the fact that a suitable transparent flexible band was commercially available, and the encouragement thus given to manufacturers and inventors, who saw a possible remunerative field for the exercise of their talents, was doubtless largely responsible for the rapid progress towards effective projection which was made during the next three years.

On September 24, 1892, Mayer filed an American specification (No. 525,991), which shows a new form of step-by-step motion (Fig. 80). A tappet, P, with inclined faces, is drawn to and fro between parallel guides by means of a crank, C, and each time the frame carrying it reaches the top or bottom of its stroke the inclined face of the tappet strikes the inclined face of a tooth, T, thus driving the drum onwards. This forward motion ended, the tappet enters the straight portion between two teeth, and so steadies the wheel. On its return journey it leaves this space centred against the slide, and the circle of teeth consisting in an odd number, there is naturally a tooth ready placed for acting on when the tappet reaches the

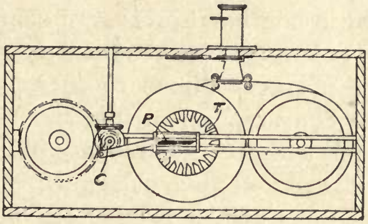

FIG. 80.

end of its stroke. After the wheel has been steadied by the tappet, a slight pressure is maintained by detent-springs to prevent accidental displacement.

In the same year (1892) a suggestion was made in *The Optician and Photographic Trades Review* which, considered from the purely theoretical side, is of considerable interest, though the practical difficulties involved are obvious. It was based on a modification of the ordinary panoramic camera, in which, as is well known, the whole camera revolves horizontally about the optical centre of the lens. The image is thrown on a film carried round a curved bearing-surface, a screen confining the action of the lens to a comparatively small angle. When the curved film

extends over 180 degrees a half-revolution of the camera forms a picture of one-half the horizon ; but if the film is fed from one side and taken up at the other a complete revolution may be accomplished and the whole horizon embraced. Let us suppose this operation completed in one-tenth of a second, and it will be plain that, given a further supply of film, the camera might make another turn, and yet another until the film was exhausted. Now, every time the lens faces any particular object it will photograph it again and again subject to the changes which it has undergone during the revolution of the camera, and if a positive be made and the operation reversed, light being thrown through the film and lens on to a screen (the projector revolving all the time), then the whole horizon may be reproduced in continual process of change on a circular screen. The chief objections to this course are that public audiences are not accustomed to a circular screen, and also that the consumption of film would be enormous; with a two-inch lens about 6¼ inches of film would be used every tenth part of a second, as against ¾ inch at present. Of course, as suggested, a part of the horizon could be screened off and other subjects taken on the protected portion of the film, but probably the collection made on one ribbon would not be universally acceptable, and the idea, ingenious as it certainly is, cannot be considered as within the range of practical politics

In June, 1893, M. Marey took a French patent (No. 231,209) for his *Photochronographe*, a slightly improved form of the apparatus shown in Fig. 74 The arrangement of its several mechanical details rendered the spacing of the individual photographs somewhat irregular, and the views were therefore of comparatively little use for subsequent projection.

Another French patent (No. 233,337) of October in the same year contains the description of M. Demeny's apparatus subsequently introduced as the *Chronophoto-*

graphe d'amateur or *Biographe*. Fig. 81 shows the principle involved in the invention. The film was reeled from one bobbin to another, being steadied in front of the aperture by a pressure-frame. The lower or taking-up bobbin was, however, mounted eccentrically, and thus on its down-stroke gave a sudden pull to the film, which then remained stationary while the bobbin rose and rolled up the film previously pulled down. In this crude form the apparatus was only adapted for taking short series; the amount of film rolled up on the lower bobbin naturally increased during working, and therefore varied the amount of film

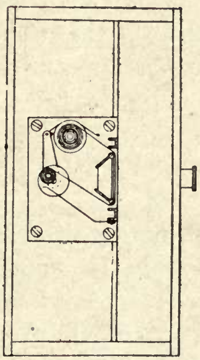

FIG. 81.

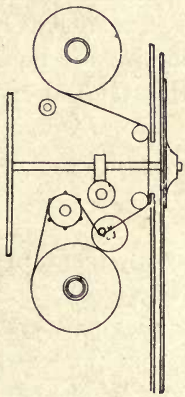

FIG. 82.

pulled down at each revolution. The error was obviously that of imparting eccentric action to the store-bobbin; had the latter remained independent and the eccentric motion been applied to an intermediate roller the action would have been constant. This fact was soon recognized, and M. Demeny incorporated a new and important modification into his German and English patents applied for only two months later—that is to say, in December, 1893. This development was not added to his French patent until July, 1894, and it is from this patent that Fig. 82 is reproduced. The eccentric motion previously applied to

the bobbin was now transferred to an intermediate portion of the mechanism, thus giving an intermittent pull to the film, constant in extent and regular in action. The film, after passing in front of the aperture, where it is steadied by friction rollers, is periodically struck by an eccentric rod or dog-motion, which draws down sufficient film to change the picture. The film is meanwhile constantly passed on at a regular rate to the store-reel by a sprocket-wheel. The specification further suggests that the eccentric need not be shaped as a rod or roller, but may take the form of a "blade," and several devices of this kind are shown in Fig. 83. This dog-motion or pitman is still extensively employed, and it is only right to recognize the name of Demeny as that of the originator of this type of machine; there does not appear to have

FIG. 83.

been any mention before 1893 of the motion used in the Chronophotographe, though, considering the number of instances in which vague suggestion has been found to have long preceded practical application, it would probably be somewhat rash to definitely affirm the statement.

In November, 1893, Friese-Greene filed an English specification chiefly remarkable for its resemblance to Varley's invention of 1890 (Fig. 73). However, as the drawing shows the cam-driven arm more clearly, it is reproduced in Fig. 84. Further extraordinary suggestions were made for utilizing the apparatus in the production of moving stage scenery; a double dissolving shutter was shown, and it was said that cobalt salts might be used to colour films in order to produce change of tint under the influence of warmth; though how this principle affects a kinetographic film (which moves at short intervals of time and is specially protected from heat) was not explained.

As a curiosity may be mentioned an idea published in 1893 in *The Optician and Photographic Trades Review.* The suggested method of working depends largely upon the optical properties of the cyclostat, an instrument for rendering a revolving body optically stationary by means of a prism rotated in the same direction as the body under observation, but at half the angular speed. If, now, we have a revolving circular sensitive surface, we can render it optically stationary by means of a cyclostat, and can take a photograph upon it by an exposure of any duration

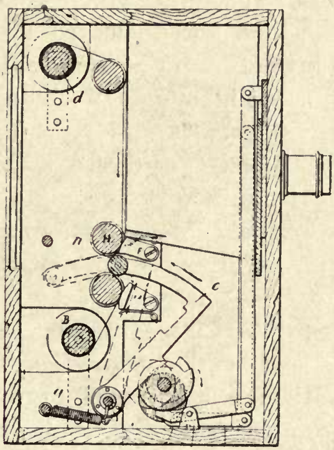

FIG. 84.

despite its continual rotation. But if the sensitive surface is formed of a portion of a flat spiral, lying on a plate through a slot in which it is fed up and withdrawn, this very action causes a rotation. This rotation will be neutralized as a whole by the cyclostat, but the portion of the spiral acted on will nevertheless be continually added to on one side and drawn away on the other. The image of any object will be therefore rendered optically stationary, but will be subjected to blurring due to its proper movement during the time that any specified

portion of the spiral is exposed, as of course is the case in every photographic exposure. But as the film dips down through the slot a fresh piece is fed up and receives the image in the same stage as the withdrawn portion, and itself starts on its circular trip. By this means the extent of blurring is kept within the usual limits. If a similar spiral positive film is fed through the slot in the same manner and viewed by means of a cyclostat a moving picture may be seen, and as persistence is not called into question, the rate of revolution of the spiral may be far slower than the speed at which the photograph was obtained and which was governed by the necessity of making one revolution in a sufficiently short time to obviate conspicuous blurring. Such an arrangement does not lend itself to projection (except aphengescopically), but would be suited for direct inspection. No trial instrument on this principle appears to have been made; the complications caused by photographic manipulation of a spiral film are probably quite a sufficient bar to the experiment.

A new principle was introduced by Jenkins in 1894, his United States specification having been filed on January 12 of that year, though not issued until May, 1896. The *Phantoscope Camera* (Fig. 85) employed a continuously moving film in front of which revolved a disc bearing a number of lenses. The speed of this disc was so determined that each picture on the film was accompanied in its travel past the aperture by an accurately centred lens; and though the film was moving in a right line and the lens in a circle, projection took place over so small an arc that the deviation from a right line was insensible. Though the lenses pass an opening in the casing, a little reflection will show that if the aperture be rightly proportioned it does not act as a shutter; on the contrary, the pictures are independent, the formation of one beginning before the exposure for the preceding one

has ceased. This apparatus should be reversible, but as a matter of fact Mr. Jenkins adopted a different system for his projecting Phantoscope which was not exhibited until 1895, nor described until 1896. The interest of the Phantoscope Camera resides in the fact of its similarity to Uchatius' arrangement of 1853 (p. 19) ; both had the image and lens in fixed relation, but while Jenkins moves image and lens together, Uchatius kept them stationary and

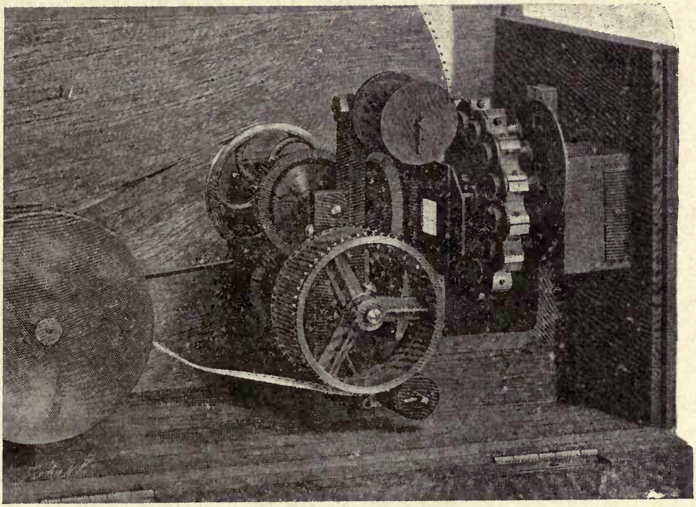

FIG. 85.

moved his source of light. This resemblance is, however, of purely historical import; no comparison is possible respecting efficiency. There is no doubt but that Mr. Jenkins not only successfully operated this form of apparatus as a camera but also employed it for projection purposes; still it may be questioned whether such a machine could be popularly introduced. In the November of 1894 the same inventor filed another United States specification (No. 536,569) for an inspection apparatus

somewhat on kinetoscope lines, but without a shutter, the film being intermittently illuminated by the action of two incandescent lamps mounted on a revolving arm.

With the commencement of the year 1895 considerable activity was manifested in the United States no less than in France and England, and it is to that year we must look for the appearance of the Living Picture in a popular and successful projection exhibition. On March 9 a most ingenious specification was filed in the United States by Gray, and subsequently issued on June 4 as No. 540,545. It is perhaps questionable whether perfect registration

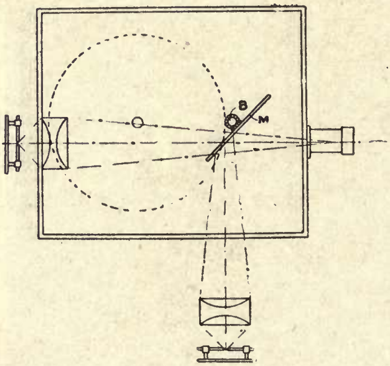

FIG. 86.

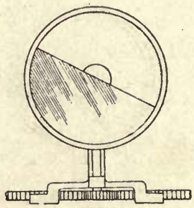

FIG. 87.

could be obtained with so many movements applied to the same film, but there is no doubt as to the novelty of the methods proposed. The apparatus being designed both for projection and securing negatives, the drawings illustrating the former purpose will serve to explain the whole method, which was one of double projection through one lens. Leaving the film out of the question for the moment, Fig. 86 shows two arc lamps each furnished with a condenser. From one of these condensers a beam of light proceeds directly to the projection lens; if this beam be disregarded, it will be seen that the

light from the other condenser is caused to follow the same path by a mirror, M, set at an angle of forty-five degees. This mirror is shown in elevation in Fig. 87, and consists of a half-circle of silvered glass, the other half-circle being transparent. The mirror is rotated by bevel gear, B; and provided that the two beams of light bear on it below or above its centre, the direct beam will pass to the projection lens when the transparent portion is in position, while the light from the lamp at right angles will be thrown on the screen when the silvered part comes round. Also, in a certain position, portions of both beams of light will reach the projection lens; that is to say, one beam of light will be vignetted into the other and

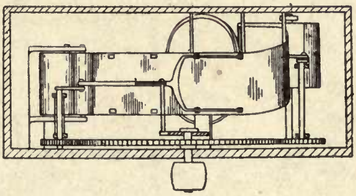

FIG. 88.

there will be no interruption of illumination. This being well understood, we will in imagination interpose the necessary film, do away with the arc lamps and condensers, and consider the apparatus to be working as a camera. Looking at Fig. 88, the film is seen coming from the right-hand, dropping to the extent of half its width, and being drawn along by forked fingers in order to be wound up on a receiving-spool. The oval seen in the middle is the mirror, in rapid rotation, but at present engaged in deflecting the beam of light in order to throw an image on the lower portion of the film on the right-hand. As it continues turning, the silvered portion passes and the beam of light traverses the transparent glass and begins to form an image on the upper part of the film

directly in front of us on the other side of the fork, and at this stage both parts of the ribbon are being acted upon; exposure at right angles is not quite finished, exposure in a right line has begun. So soon as the mirror has turned sufficiently to allow the whole beam of light to come straight on in the ordinary way, the exposure at right angles terminates and that part of the ribbon is moved on by a similar fork to that seen in Fig. 88, thereby throwing up a loop. In the same way, when the mirror begins to cut off the direct light it also commences a new exposure on the fresh surface at right angles, but there is always a time when both portions of the ribbon are stationary and receiving concurrent impressions. The result is a ribbon bearing a double set of pictures, the upper series being

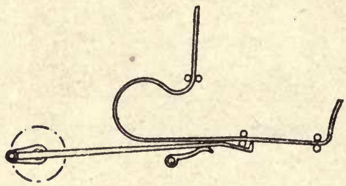

FIG. 89.

obtained direct, the lower at right angles, and every one vignetting, so to speak, into both its predecessor and successor. The claws are driven to and fro by a crank, as shown in Fig. 89, the tooth dragging over the film in one direction, but being pressed into the perforation by a spring when travelling the other way. The complication of a triple movement of the film would doubtless render accurate registration somewhat difficult with this apparatus, and it may be thought that more emphasis has been laid on it than it deserves; but when it is remembered that this machine contains the first of a long series of claws and spring teeth for moving the film, and also shows a semi-circular rotating mirror for deflecting the light (a device patented in another connection at a far

later date), it will be conceded that the ingenuity displayed by the inventor calls for recognition.

A few days later, on March 25, 1895, Eames filed a specification in the United States, subsequently issued as No. 546,093, showing an arrangement which could only be called an improvement on Jenkins' Phantoscope Camera if the question be considered in an economic sense. The number of lenses was reduced to two, a substantial saving in expense of construction, but the disadvantages introduced appear to outweigh the saving secured. It is of almost vital importance that the individual views be obtained from the *same point of view;* if succeeding pictures be secured by lenses placed side by side, a variation in position of foreground objects results as a matter of course; and this variation, which is essential in stereoscopic work, is prejudicial under other circumstances and bound to cause a false vibration of objects on the screen. It cannot be denied that enough trepidation is liable to exist in the average Living Picture without risking a further importation of so little desirable a characteristic! Still, the *Animatoscope* is a distant type of machine, and as such it must be described. A single film is employed; but this film is of double width, and travels continuously downwards behind a pair of lenses mounted on sliding panels (Fig. 90). A circular shutter, furnished with two slots, each extending halfway round, revolves between lens and film. Presuming that exposure has just commenced with the right-hand lens, the cycle of operation is as follows. The film descends at a fixed rate, so also does the lens, it being drawn down by the crank-rod attached to the front panel. The lens does not, however, travel at exactly the same speed as the film; the moving parts are so geared that when used for projection purposes a line connecting the centre of the picture with the centre of the screen shall always pass through the optical centre of the lens. While this right-hand lens is descending, the

left-hand one is rising, but has no action on the film because the light is cut off by the shutter. So soon as the lens begins its descent light is admitted to act, and at this time the position of affairs is such as to display the characteristics of the machine. One lens has reached the bottom and is just terminating its exposure; the other lens is situated at half a picture height above and is just commencing to act. The result is shown in Fig. 91, where the two series of pictures are seen side by side upon the film, the upper margin of one picture being level with the centre line of that which follows. The speed of the

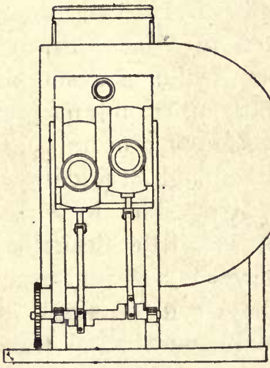

FIG. 90.

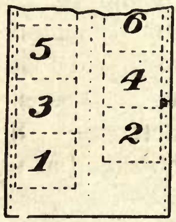

FIG. 91.

film is therefore reduced to one-half, the alternating exposures or projections overlap, and all parts of the apparatus are in continual movement. By these means it is claimed that unsteadiness is avoided, while it is certain there is no interruption of light either in camera work or exhibiting.

And now the turning-point in the History of the Living Picture is reached. Up to this date the Kinetoscope was the only instrument of a distinctly popular nature, and it may be safely affirmed that, whatever may have been done in the way of private experiment, no public exhibition of a

projected Living Picture had been a popular success. With the advent of Messrs. Lumière's *Cinématographe*, however, this desirable consummation was attained, and to them must be attributed the credit of stimulating public interest to such a pitch as to lay a firm foundation for the commercial future of cinematographic projecting apparatus. It was on February 13, 1895, that Messrs. Lumière filed their French specification No. 245,032, their English patent being dated April 8. To the French documents four or five additions were made, and a further English patent was taken a year later. As, however, these additions are but slight expansions of the original ideas, it is perhaps as well to describe them together. It may be mentioned that the Cinématographe was exhibited at Marseilles in April, 1895; and a display given at Paris in the following July was the commencement of a career of unequivocal success. The beauty of the Cinématographe resides as much in its simplicity as in the results obtained, and no apology is required for a somewhat lengthy description being given of a machine which has attained a position of historical importance. Fig. 92 shows the casing opened, while Fig. 93 clearly exhibits the hidden mysteries. First and foremost let it be supposed that the machine is arranged with a view to projection; the film-spool is placed in a holder at the top and the film is led through the machine. It will be seen that the film is provided with two holes only to each picture, one on each side. Briefly stated, the action of the machine is as follows. A picture is at rest opposite the lens, but so soon as a rotating shutter cuts off the light two little pegs enter a pair of perforations and then sink down, carrying the picture band with them to the exact extent of one view. The pegs then come to rest, steadying the film, and are withdrawn in order that they may rise preparatory to drawing down a fresh portion. While they are rising the shutter passes away and allows the stationary picture to

be projected. How this is accomplished will be understood by reference to Fig. 93. The pegs are carried by an arm, B, fixed on a frame, A, which is driven up and down by a central cam. A rotating arm, working from the same centre as the cam, has wedge-shaped ends, and the pins are not rigidly fastened to the arm B, but are formed like the prongs of a little fork which can slide backwards and forwards. Every time the pegs arrive at the top, the wedge on the end of the rotating arm acts against another wedge, D, on the fork and drives the pegs into the perfora-

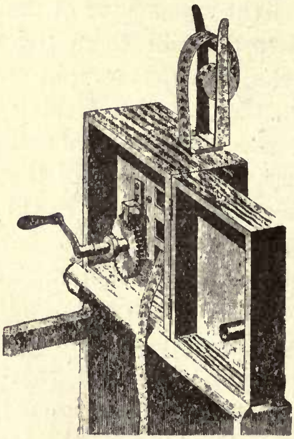

FIG. 92.

tions. This done, the frame, pegs, and film sink together. Arrived at the bottom, the other end of the arm, furnished with a wedge slanting the other way, comes round and acts on the other side of D in order to draw the pegs out so that they may rise without moving the film. This is the whole principle of the machine in its simplest form, but its efficiency depends on an important modification. If the central cam were a disc, as shown in Fig. 93, the frame would take as long to make its downward journey as it would to travel in the reverse direction; and, further,

the motion would be continuous. Therefore the cam is formed as shown in Fig. 94, with the result that while the cam turns through 60 degrees the frame remains stationary for the insertion of the pegs; a further movement of

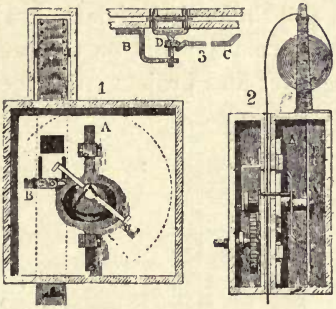

FIG. 93.

120 degrees drops the frame, the pegs drawing the film down. During the next 60 degrees of rotation the frame remains still to allow the pegs to be withdrawn, while the 120 degrees required to complete one rotation are occupied

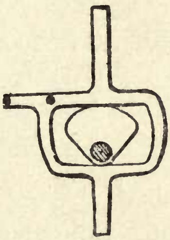

FIG. 94.

by the rise of the frame. Therefore the film is only in movement for one-third of the total time of one revolution. Some further modifications are shown in Fig. 95. Instead of driving the cam at a regular speed, the toothed wheel S may so act on the shaded wheel as to cause it to rotate

more quickly at one period than another, and in consequence the film may be drawn down quickly, while the raising of the pegs occupies a longer time. As the film is stationary during the rise of the pegs, the picture may be projected for considerably more than one-third of a complete revolution, and the period of darkness is consequently reduced. The two arms that act on the pegs are therefore placed closer together and project from the edge of a disc,

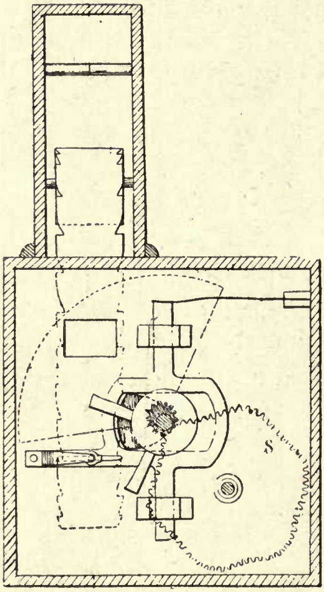

FIG. 95.

better seen in Fig. 96. Subsequently these arms disappeared, their functions being discharged by variations in the surface of the disc itself; but the latest developments of this type of machine will be illustrated in the next chapter.

While Messrs. Lumière were triumphing over their difficulties in France, the problem was also being attacked on this side of the Channel. It is certain that Mr. Birt

Acres was working concurrently with Messrs. Lumière, for he photographed the University Boat-race with his *Kinetic Camera* on March 30, 1895, only a few days after Messrs. Lumière filed their French patent, and before the deposit of their English one. In fact, Mr. Acres appears to have been beaten all through the race by a few days; his English patent is dated about five weeks after Lumière's, and he does not appear to have given a public exhibition until the early days of 1896. But this point is of little importance, for his apparatus was constructed on distinctly different lines to those adopted in the Cinématographe. Fig. 97 shows the *Kinetic Camera*

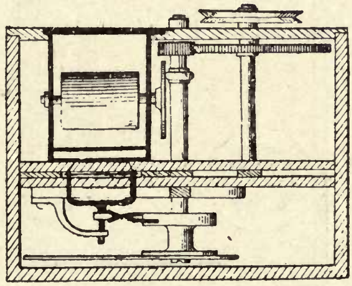

FIG. 96.

at the commencement of an exposure. The film is firmly held by the shaded clamping-frame F, pressed home by the black cam C. While exposure is proceeding the upper sprocket-roller is feeding out an exact picture-length—that is to say, it moves four teeth forward. So soon as the shutter cuts the light off the clamping-frame is loosened, and the roller R, which has been bearing against the film, is thrown into its shaded position by the action of a spring, thus drawing down the slack which has accumulated above the clamp and substituting a fresh sensitive surface, which is at once firmly held in position. A fresh exposure now commences, during which the bottom sprocket-roller takes up the looped film and so gradually forces the roller R

back into its original position, ready to act again when the clamp is taken off. This apparatus has undergone several christenings. Brought out in January, 1896, as the *Kinetic Lantern*, this term was abandoned the following March in favour of the name of "*Kineopticon*." Being called to give an entertainment before the Prince of Wales in July, the inventor found, to his surprise, that the programmes issued under Royal auspices referred to his invention as the

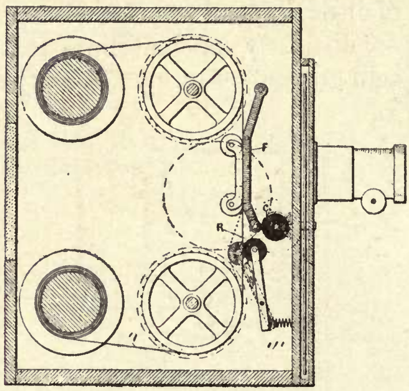

FIG. 97.

"*Cinematoscope*." What could a loyal photographer do except follow the same course as Mr. Acres actually did? Cinematoscope it was by Royal dictum, and Cinematoscope it remains to this day. But as "a rose by any other name would smell as sweet," so did the Cinematoscope retain its good qualities under all its varied nomenclature.

Paul also was pioneering the Living Picture as a source of entertainment. The Prince's Derby was filmed in 1896, and re-run at the Alhambra within twenty-four hours of the event, after which the Animatograph became permanently installed there.

These exhibitions in France and England demonstrated very clearly to the then few enthusiasts the possibilities of

Living Pictures for entertainments. It is, however, at least doubtful if anyone at the time realized the full extent of their possibilities. The sudden jump in the number of inventions after the year 1896 is itself an indication not only of the increasing amount of ingenuity exercised in perfecting methods and apparatus, but also to the increasing popularity of Living Pictures. We have now also come to a point at which it is necessary to abandon strict chronological order and to give a separate account of the different branches of the subject.

CHAPTER IV

FILM MACHINES AND INTERMITTENCE MECHANISMS

UNDOUBTEDLY the most important developments in Living Picture projectors are those in connection with film machines, the popularity of these machines being largely owing to the great conveniences of a long film, which is light, portable, and comparatively cheap, and can be rolled into a small compass.

A much greater variety of design has been introduced than is commonly supposed, and an introductory view of principles will greatly assist subsequent comprehension of the working of different machines.

Apart from design and structure, the common and central feature of all machines is a long film, bearing a series of pictures and means for intermittently rendering the successive views actually or apparently stationary. These methods of intermittence form the subject for the present chapter, and it is desirable to include in our survey not only devices which have come into actual use, but also others which, although not so fortunate, nevertheless, have some distinctive characteristic. That a particular type of machine has not found its way into general use is not a final test of merit. Indeed, the efficiency of any given type of apparatus depends even more on the excellence of workmanship than on the mechanical devices employed; and improved design is of little ultimate advantage unless accompanied by a more than equal advance in accuracy of construction. The action of a Living Picture machine is in every respect

comparable to that of a watch or a clock, and as regards these latter it is certain that workmanship is the main factor in the results attained; no doubt an English chronometer greatly excels a machine-made watch, but only on condition that far greater care is exercised in its construction; if this be not so, the probability is that the commoner article will prove the more satisfactory. So it is with Living Picture machines. The advantages and disadvantages of different machines may be discussed till no doubt remains as to which is best theoretically, but even then the final test can only be the performance of the individual machines, even though both are of exactly the same design. Therefore, in considering the various types of machines it must be taken for granted that the workmanship is perfect, and this assumption can only be verified by inspection of the machine in actual operation.

The number of suggested mechanisms for obtaining intermittence is so very large that a selection for more detailed consideration is necessary, but various lists of British patents dealing with different types of machines and mechanisms are given in Appendix I. It has been stated that the "description of an appreciable number of these mechanisms would be a somewhat heavy and monotonous task," but it is hoped that, heavy and monotonous as the task of selection may be, the reader may yet be spared the mental indigestion, which is the author's due and his alone.

To proceed then to principles. The different classes of intermittence mechanisms may be considered according to the movement of the film. Thus the film may be moved—

1. Continuously (as, for example, in Donisthorpe's machine, or the Phantoscope see—Figs. 69, 85); and—

(*a*) Seen for a very short period;
(*b*) Rendered relatively stationary;
(*c*) Rendered optically stationary.

2. Intermittently (as in Lumière's machines—see Figs. 92-95)—

(*a*) By a sprocket-roller.

(1) Through interaction of a wheel with teeth or pegs (including Maltese cross feed mechanisms);

(2) Through interaction of a wheel or pin-teeth with a worm or cam;

(3) By the changing position of the sprocket-feed-rollers;

(4) By ratchet gearing.

(*b*) By the periodic grip of two rollers.

(*c*) By teeth.

(1) Always in contact with the film (spring-teeth);

(2) Inserted and withdrawn (claw feed).

(*d*) By pressure of—

(1) A revolving eccentric;

(2) A reciprocated arm.

(*e*) By other means than the above.

1 (*a*). *Continuously Moving Film seen for a very Short Period.*

This type is primeval. The Phenakistoscope worked on this principle, and Plateau's "Diable soufflant," was essentially similar, although the speed of image was reduced. From these two instruments were derived all such machines as the Lantern Wheel of Life, the Zoopraxiscope, and, in a degree, the Phonoscope; while Edison's Kinetoscope and Anschutz's coin-freed Electric Wonder fall into the same category. In the latter a Geissler tube is momentarily illuminated when the picture comes under the viewing-slot. In Petit's multiple view Kinetoscope, Fig. 98, an endless band, B, moves in a direction opposite to that of the film L, and is pierced with slots to act as a

shutter. The apparatus is driven electrically, the motor being reversed to return the film to its original spool. In

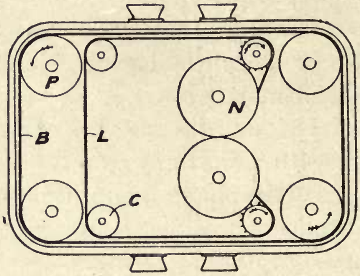

FIG. 98.

another form of apparatus, Fig. 99, the shutter is a slotted drum revolving between the light and the film. In a still

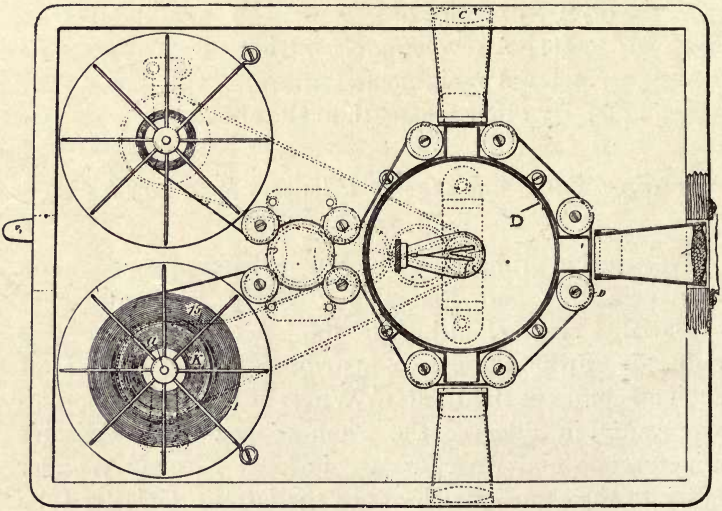

FIG. 99.

more recent apparatus the shutter consists of two concentric cylinders, each with a slot, and the picture is seen

through the viewing eyepiece when the openings coincide. But although even in so elementary a type of apparatus there is some scope for suggestion and improvement, there are comparatively few machines of this type. The reason is not far to seek. Seeing that the vision is momentary, it is clearly necessary that a sufficient amount of light should pass through the slot. Lommel, in 1881, attacked the problem by throwing a condensed beam of light through a narrow aperture working in the focal plane of the condenser, and this same system reappears in Latham's invention (No. 4,841 of 1896), though in a considerably elaborated form.

1 (*b*). *Continuously Moving Film rendered Relatively Stationary.*

Of this class there appears to be only one example—viz., Donisthorpe and Croft's machine, shown in Fig. 69. In this case, object, lens, and image are all maintained in fixed relation; devices which move lens and film together are better regarded as belonging to the next class.

1 (*c*). *Continuously Moving Film rendered Optically Stationary.*

The first attempt to render an image optically stationary was probably made by Clerk-Maxwell in 1869, as explained in Chapter II. His arrangement of concave lenses instead of zoetropic slots is of interest in conjunction with Jenkin's Phantoscope, already described, and Maskelyne's 1896 rotating lens drum. The stationary images are in both cases obtained by virtue of the changing position of the refracting surfaces of the lenses used. In Jenkin's machine the film is moving in a right line across the aperture while the lens is moving in a circle. In Maskelyne's Mutagraph (Fig. 100) the film is rendered optically stationary by means of a drum, L, composed of a number of concave

lenses, which are fixed edge to edge in a suitable frame. The film passes across the exposure aperture in contact with the drum. Inside the drum L are two stationary lenses on the line of the optical axis, the curvature of one or both of these lenses corresponding to that of the lenses on the drum. On the outside of the drum is the projecting lens, while the source of light and the condenser are behind the film. The effect produced is as follows: Each successive picture on the film, in passing across the field of view, coincides with one of the lenses on the drum. The light passes through the picture on the film, thence through the corresponding lens nearest to it on the drum, the two fixed lenses, and the corresponding lens on the other side of the drum, and then through the objective, reproducing the picture on the screen. When any picture is central with the optical axis, the faces of the various lenses will be parallel, and act as a piece of plane glass or as a simple lens, and the light suffers no deviation from its course. As the parts move, the refracting surfaces change position, and the deviation thus introduced precisely compensates for the movement of the picture, and causes its image to remain stationary upon the screen. Means are provided for giving an independent motion to the sprocket-roller in order to accurately centre the film either at starting or during working. It was an instrument of this kind which was taken to India in order to secure a view of the total eclipse of the sun. Sad to say, the film disappeared on its journey home, and neither the Wizard of Piccadilly nor a reward of £50 succeeded in bringing the errant eclipse to light.

The suggestion is made in Stroud's specification (No. 4,661 of 1898) that lenses such as are used upon the drum L should be mounted over pulleys, so that both the lenses and the film would then have a rectilinear motion across the exposure aperture. In another apparatus a cylindrical lens, 25, Fig. 101, is mounted in the aperture of

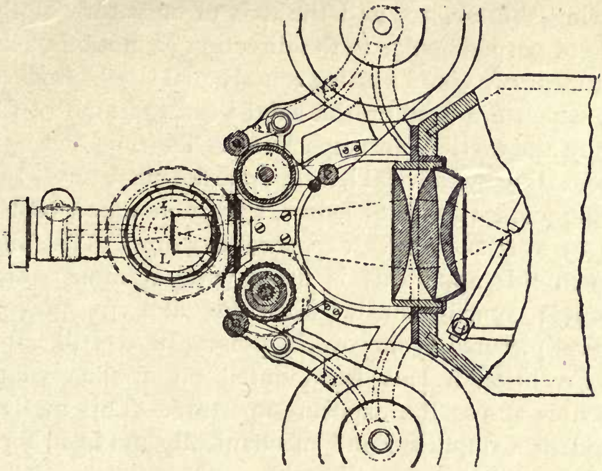

FIG. 100.

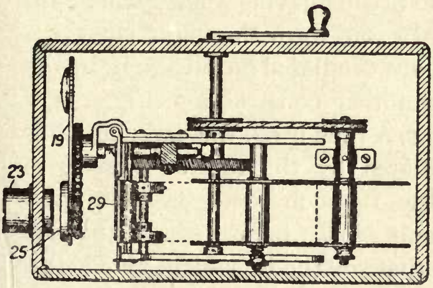

FIG. 101.

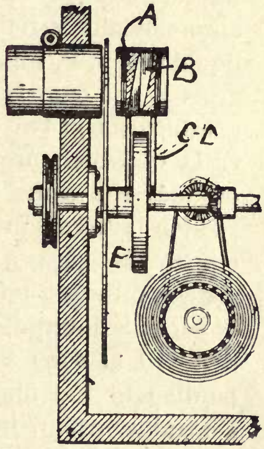

FIG. 103.

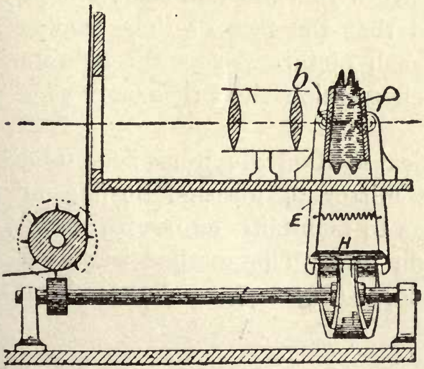

FIG. 102.

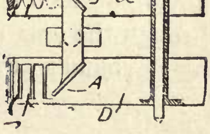

FIG. 104.

a revolving shutter, 19, and the axis of curvature of the lens is kept perpendicular to the direction of motion of the film by the use of a chain passing round equal sized sprocket-wheels, which are fixed on the axial bearing-frame of the shutter 19 and on the lens respectively. The objective 23 is a compensating cylindrical lens of opposite curvature. For projecting work a series of lenses, 25, are mounted on the shutter 19 over successive exposure apertures. The film gate 29 in this apparatus is fitted with a frame which reciprocates synchronously with the film to prevent successive pictures from overlapping. In a still more recent invention a lens is mounted on a slide which reciprocates across the exposure aperture. This method was used in a duplicate and mechanically modified form in the Animatoscope (see Fig. 90).

Other devices for producing the variable deviation of the luminous rays include prisms having angles which are automatically variable. In one form the outer faces of a liquid prism, P, Fig. 102, are oscillated on pivots, B, by the arms E and cam H; in another construction, Fig. 103, a combination of two prisms, A B, is used, the carrying arms C D of which are oscillated by the rotated cam E to produce the same result. In such methods there is a sudden return movement just before each picture enters the gate. In other methods which avoid this sudden return, a refracting prism having an even number of faces is interposed between the film and lens, and is revolved at such a speed that the face of the prism is parallel to the film as each picture passes through its central position, in which position the prism acts as a piece of plain glass.

Another important optical method which has been used is the employment of a mirror or mirrors, turning or moving at such a speed as to maintain the beam passing through the lens in a right line. This method was used in Reynaud's Praxinoscope (Fig. 22), and has been

modified and developed by many inventors. One modified form of such apparatus described by Stroud (No. 4,661 of 1898) is interesting. The pictures (P, Fig. 104) are on one drum, D, and two stationary mirrors, A B, are used in conjunction with a series of lenses on the periphery of a concentric parallel drum, D. In Casler's apparatus (Fig. 105) the film passes from the feed-roll 2 to the store-spool 3 in contact with the segmental frame 16. This frame swings from right to left at the same speed as the film, and is so arranged that when starting on an oscillation a picture is outlined by the opening 27. Light passes through this opening and the picture to a mirror, 22, which is moved

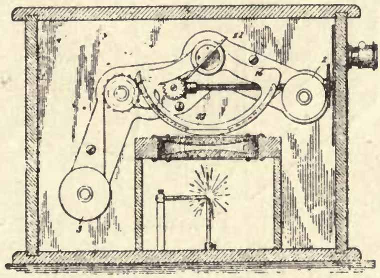

FIG. 105.

by gearing at half the angular speed of the frame; consequently the rays are maintained optically stationary with regard to the projection-lens. When the frame reaches the extremity of its movement to the left, both it and the mirror are rapidly returned to their original positions by means of cams. In Campbell's apparatus (Fig. 106) the band runs over a drum, being drawn from a box, 8, and is illuminated by a mirror, 22. As it is only designed for inspection purposes, the pictures are seen through magnifying eyepieces, 6, the rays being rendered optically stationary by the mirror 5, tilted by a lever, 19, the latter being actuated by pegs, 20, on the drum. In addition it is suggested that the instrument may be

employed (of course without the film) for the inspection of machinery, etc. Britain's apparatus (Fig. 107), described

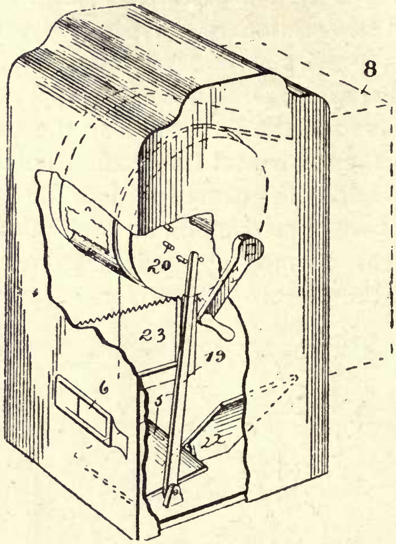

FIG. 106.

in specification No. 2,575 of 1899, is of interest in connection with Gray's apparatus of 1895 (see Fig. 86). A semi-

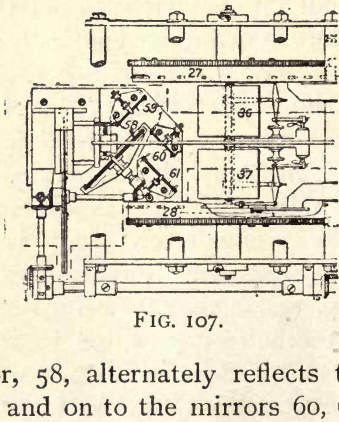

FIG. 107.

circular mirror, 58, alternately reflects the light on to the mirror 59 and on to the mirrors 60, 61. Light thus

alternately reaches the oscillating mirrors 36, 37, which are rotated at half the angular speed of the cylinders, 27, 28, over which the film of double width passes. The mirrors 36, 37 thereby alternately project a stationary image on the film, and are alternately inactive on the return movement. In other apparatus of this kind two mirrors oscillating on a common axis, and actuated by cams, are used alternately, and a cylindrical or other shutter cuts off each mirror on its return movement. In Barr's invention (No. 8,245 of 1899), a rotating helical mirror (*b*, Fig. 108) reflects the light from the condenser or camera objective *h k* on to the moving film *f*, thereby causing the beam to travel with the film. For projection work a

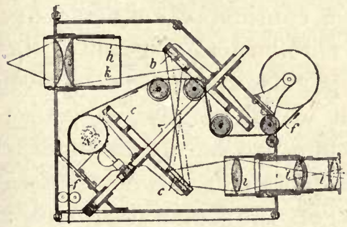

FIG. 108.

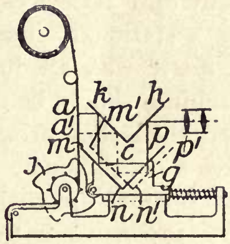

FIG. 109.

similar mirror, C, reflects the light passed through the film, through the projector *i*. The feed-rollers for the ribbon and the shaft carrying the mirrors are geared so as to maintain the required velocity ratio between the film and mirrors. In Lumière's invention (No. 7,482 of 1905), Fig. 109, two perpendicular mirrors, *m n*, *n p*, are movable in a direction *n n'* at right angles to the plane bisecting the mirrors. If a point *a* on the film moves to *a'* in a line parallel to *n n'*, while the mirrors move half this distance (*i.e.*, *a a'* equals 2 *n n'*), into the position *m' n'*, *n' p'*, it will be seen that the direction of the twice reflected image will be the same, and will appear to come from the original position *a*. In the projector, Fig. 109, two stationary

mirrors, *k c*, *c h*, are used so that the film and objective may occupy convenient positions. The moving mirrors *m n*, *n p* are mounted on a carriage, *g*, which is oscillated by a cam, *j*, and an opposing coiled spring. During each return movement the objective is closed by a shutter. The suggestion is made that an endless chain of such double mirrors may be formed and used in lieu of the oscillation carriage. More recently it has been proposed to utilize a series of small mirrors mounted on the periphery of a rotating drum, the projecting light passed through the moving film being reflected from these mirrors through the projecting lenses.

There can be no question as to the ingenuity of the many optical devices such as the foregoing for maintaining a stationary image with a continuously moving film. If merit was an infallible corollary to ingenuity, such machines should be far more popular and more extensively used than they are. That it would be advantageous to have a continuously moving film can hardly be doubted. One obvious drawback to these methods is the necessarily very expensive optical part of the apparatus, and as between a rapidly moving optical system and an intermittently moving film, experience has decided in favour of the latter. As regards the comparative utility of the various optical methods, it would be very different to attempt anything like a detailed comparison. The suggestion may, however, be made that such devices in which the optical system moves continuously would probably be more efficient and mechanically more convenient than those in which the optical system has a reciprocating motion.

Intermittent Feed Devices.

There are three essentials for a good machine—(1) During the time that any picture section is in the gate, it must be absolutely steady. There must not,

therefore, during this "stationary period" be any pull on the film by the driving mechanism. As a rule the gate is fitted with auxiliary means for steadying the film. (2) In order to secure sufficient illumination, the stationary period during which each picture is in the gate should be as long as possible in comparison with the time interval before the next picture occupies its place. (3) In order to avoid undue wear and tear on the film, and particularly on the sprocket-holes along the edges, there should be no sudden pull or jerk on the film during a shift.

2 (*a* [1]). *Film moved intermittently by a Sprocket-Roller through Interaction of a Wheel with Teeth or Pegs.*

To introduce this class an illustration may be given which has nothing whatever to do with the Living Picture. In fact, a prize might be offered for the first correct answer

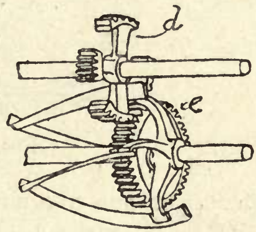

FIG. 110.

as to the use of the apparatus shown in Fig. 110; but as there are no prizes, it may be stated at once that the figure is a drawing of a lawn-mowing machine with projecting knives. Nevertheless, it will serve better than any other as a foundation for the discussion of principles. Let us imagine the wheel *e* to be joined to the axis of the ordinary sprocket-roller; it will be seen that if the upper axle were rotated the wheel *e* would be partially revolved every time the segment *d* acted upon it. Further, if the segment

contained the right number of teeth, the wheel *e* might be rotated to the exact extent necessary to draw the film one picture-length onward. The reason why a movement of this simple description would be ineffective is found in the fact that the film requires to be started and stopped many times a second. The momentum of the wheel *e* and the film would carry the film on further than one picture-length at each stroke. But as we have seen, an exactitude in starting and stopping the film is one of the first essentials for a Living Picture machine.

The simplest form of this class of mechanism is obtained by rearranging the teeth on the large wheel and reducing

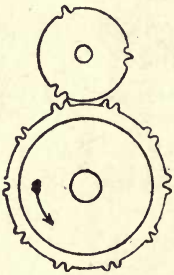

FIG. 111.

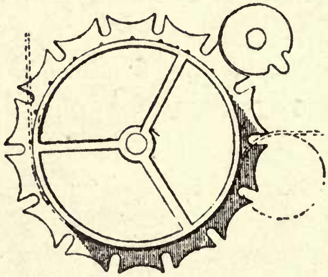

FIG. 112.

the segments on the upper one to a single tooth each, as seen in Fig. 111. Here it is the large wheel which is driven by the smaller, the large wheel standing still until a fresh tooth comes round, the plain part of the upper wheel resting against two teeth on the lower one, which is thus steadied. A further development of this plan is seen in Fig. 112, where a small fly-wheel only bears one tooth, the rest of the circumference being specially adapted to rest against the specially shaped intervals between the slots in the large wheel in order to effectively steady it. The single tooth may be replaced by a pin, P, and the large wheel by a Maltese cross, M, Fig. 113. The pin P, standing out from the disc D, enters a slot in the

Maltese cross, which is attached to the sprocket-wheel, gives it a quarter turn, and then passes on, leaving the shaped portion N of the cross steadied by the raised portion S of the pin-disc D. This arrangement moves the cross once for every revolution of the pin-disc. If the latter bears two pins, it will, of course, act twice instead of once during each revolution. It is usual to use rollers in order to reduce friction. Both the sprocket-roller feeding the film and the roller drawing the film through the gate may be simultaneously actuated by the use of two slotted

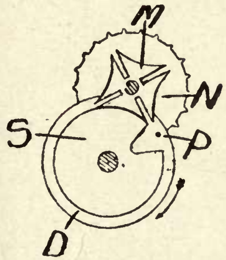

FIG. 113.

FIG. 114.

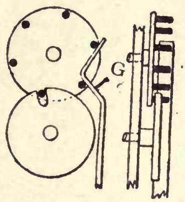

FIG. 115.

wheels, M, M′, Fig. 114, and a pin-disc, D, with two pins, P. This arrangement was adopted by Paul in one of his early machines. If desired, the whole arrangement may be reversed, and instead of the pin driving the slot, the slot may drive the pin. In one suggested form, illustrated in Fig. 115, the lower slotted disc pushes one pin on at each revolution, driving the previous one past the spring grip G, which then locks the wheel in exact position.

This Maltese cross motion is one employed for many years past in horology under the name of the Geneva

stop, wherein the arms of the cross were hollowed at their ends so as to bear very accurately against the curved edge of the pin-disc exactly as shown in the drawings. One of these arms, however, was not hollowed, and therefore locked against the disc in order to prevent further rotation, which would have resulted in over-winding; hence the name of stop. Though this stopping motion was its first use, the arms were soon made alike, thus permitting continual rotation, and the device has long been employed in various branches of mechanical engineering to convert continuous into intermittent motion on

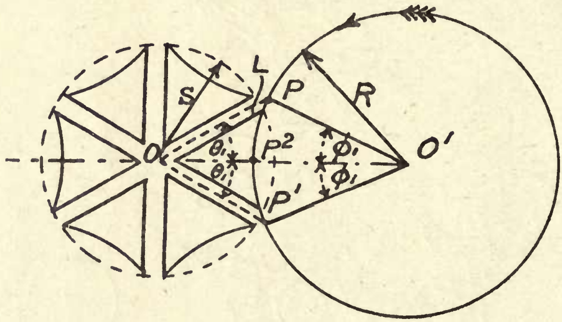

FIG. 116.

exactly the same principles as those applied to the machines under present discussion. The motion was one of the earliest in the field, and is still the most popular, and the one most extensively used.

As already pointed out, the stationary period during which any picture is stationary in the gate should be as large a portion as reasonably possible of the interval before the next picture takes its place, which interval we will call the succession interval. These related periods will depend on the relative sizes of the film-wheel and the Maltese cross or slotted wheel, and upon the number of pins and slots. The effect of varying these quantities

can be seen very clearly by the aid of very elementary mathematics.

In Fig. 116, O and O′ represent respectively the driven slotted wheel and the driving pin-wheel respectively. The pin P is shown just about to enter one of the slots, and the pin emerges from the slot at P′, leaving the next slot in position for the same or another pin P.

Let n = the number of pins on the pin-wheel O′.
R = the radius of the circle described by the pins.
S = the radius of the slotted wheel or cross O.
s = the number of slots.
$2\theta_1$ = the angle between consecutive slots.
$2\phi_1$ = the angle swept out by the pin P during one shift.
v = the number of revolutions per second of the driving pin-wheel.

Then from these data we have—

The number of shifts per second $= nv$,

the succession interval $= \dfrac{1}{nv}$,

the angular velocity of the pin-wheel $= 2\pi v$,

the number of slots s $= \dfrac{2\pi}{2\theta_1} = \dfrac{\pi}{\theta_1}$.

$$\text{The relative stationary period} = \frac{\text{stationary period}}{\text{succession interval}}$$

$$= \frac{\dfrac{1}{nv} - \dfrac{2\phi_1}{2\pi v}}{\dfrac{1}{nv}}$$

$$= 1 - \frac{n\phi_1}{\pi}.$$

It will thus be seen that the ratio is larger or smaller according as n and ϕ_1 are smaller or larger. The effect of

increasing the number of pins is to lessen the relative stationary period, while on the other hand the effect of increasing the size of the pin-wheel is to increase the relative stationary period. In practically all modern Maltese cross machines one pin only is used, and the size of the pin-wheel adjusted to give whatever ratio is desired.

Another important point in the Maltese cross motion is the manner in which the pin enters the slot. It will be seen from Fig. 116 that just when the pin P enters the slot O P its motion is perpendicular to the radius O′ P. If this direction is radially along the slot O P, then there will be no impact on the surface L of the slot; if, however, this direction is not radially along the slot (which case is illustrated in Fig. 116) the pin P will impinge on the surface L of the slot and start the slot-wheel with a sudden jerk. The radial entry into the slot was advocated by Paul in 1899, and in this case

$$\phi_1 = \frac{\pi}{2} - \theta_1 = \frac{\pi}{2} - \frac{\pi}{s}.$$

$$\text{The relative stationary period} = 1 - \frac{1}{2} + \frac{1}{s}$$
$$= \frac{1}{2} + \frac{1}{s}.$$

This ratio is a maximum when s is as small as possible, and the smallest possible number of slots is three. With three slots, therefore, the stationary period is five-sixths of the succession interval.

The motion of the star-wheel and feed sprocket geared therewith during the shift interval is also of interest, and also that of the consequential motion of the film. If we further consider the motion of the wheel O (Fig. 116) during any shift interval, the angular velocity starts from zero, increases to a maximum as the pin P crosses the line O O′ at the point P^2, and decreases to zero when the

pin leaves the slot. This motion of the star-wheel and of the film may be further investigated as follows:

Let p, in Fig. 117, be any point in the travel of the pin when in the slot coinciding with the radius O p.

Draw p M perpendicular to O O′.

Let θ and ϕ represent the angles p O O′ and p O′ O respectively.

$$\text{Let} \quad \text{O O}' = \text{C (a constant quantity).}$$

$$\text{Then } p\,\text{M} = \text{R} \sin \phi = \text{O M} \tan \theta$$

$$= (\text{C} - \text{R} \cos \phi) \tan \theta \ldots\ldots (1)$$

$$\text{Also,} \quad \text{C} = \sqrt{\text{R}^2 + \text{S}^2 - 2\,\text{R S} \cos \text{O}\,p\,\text{O}'} \ldots\ldots (2)$$

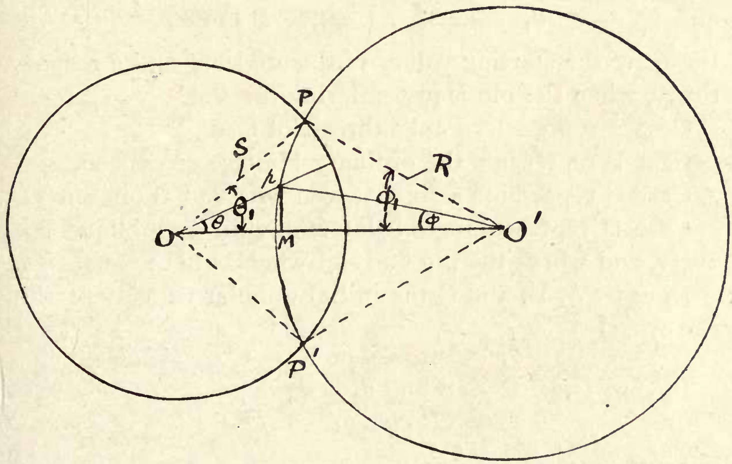

FIG. 117.

Differentiating equation (1) above, we have—

$$\text{R} \cos \phi\, \dot{\phi} = (\text{C} - \text{R} \cos \phi) \sec^2 \theta\, \dot{\theta} + \text{R} \sin \phi \tan \theta\, \dot{\phi} \ldots (3)$$

Now $\dot{\phi}$ = the angular velocity of the pin-wheel,

$$\text{and} \quad \sec^2 \theta = \left(\frac{\text{O}\,p}{\text{O M}}\right)^2$$

$$= \frac{\text{R}^2 + \text{C}^2 - 2\text{R C} \cos \phi}{(\text{C} - \text{R} \cos \phi)^2} \text{ from } \triangle\, \text{O}\,p\,\text{O}'.$$

Hence from equations (1) and (3)

$$\dot{\theta} = \frac{R\,(C \cos \phi - R)}{C^2 + R^2 - 2\,R\,C \cos \phi}\,\dot{\phi} \,\ldots\ldots\ldots (4).$$

This equation (4) thus gives the angular velocity $\dot{\theta}$ of the star-wheel in terms of $\dot{\phi}$, which is the known velocity of the pin-wheel at any instant of the shift movement determined by the value of ϕ. By taking different values for ϕ, the relative velocity of the star-wheel can be represented by curves.

We may take, for example, four typical cases as indicated in Fig. 118.

Let ϕ_1 represent the angle P O′ O,
and θ_1 „ „ „ P O O′;

these are the starting values of the angles ϕ and θ respectively, when the pin is just entering the slot.

Case A represents Paul's three-slot feed.

Case B represents the ordinary Maltese cross feed.

Case C represents a six-slot feed with radial pin entry.

Case D represents a six-slot feed with an oblique pin entry, and where the pin and slot-wheels are of equal size.

In cases A, B, and C the initial angular velocity of the slot-wheel

$$\dot{\theta}_1 = \text{zero, since } R = C \cos \phi_1.$$

In case D, $R = S$ and $\theta_1 = \phi_1 = 30°$.

$$C = 2R \cos 30° = \sqrt{3}\ R.$$

∴ from equation (4)

$$\dot{\theta}_1 = \frac{\sqrt{3} \cos 30° - 1}{4 - 2\sqrt{3} \cos 30°}\,\dot{\phi}_1$$
$$= \tfrac{1}{2}\,\dot{\phi}_1\,;$$

that is, the slot-wheel is jerked forward with one-half the angular velocity of the pin-wheel.

The motion of the slot-wheel can be represented by a series of curves A, B, C, D, such as shown in Fig. 118, corresponding to the cases A, B, C, D, and in which the

height of the curve at any point of the ϕ axis represents the velocity of the slot-wheel when in the stage of its feed movement corresponding to that point.

The motion of the film itself is determined partly by

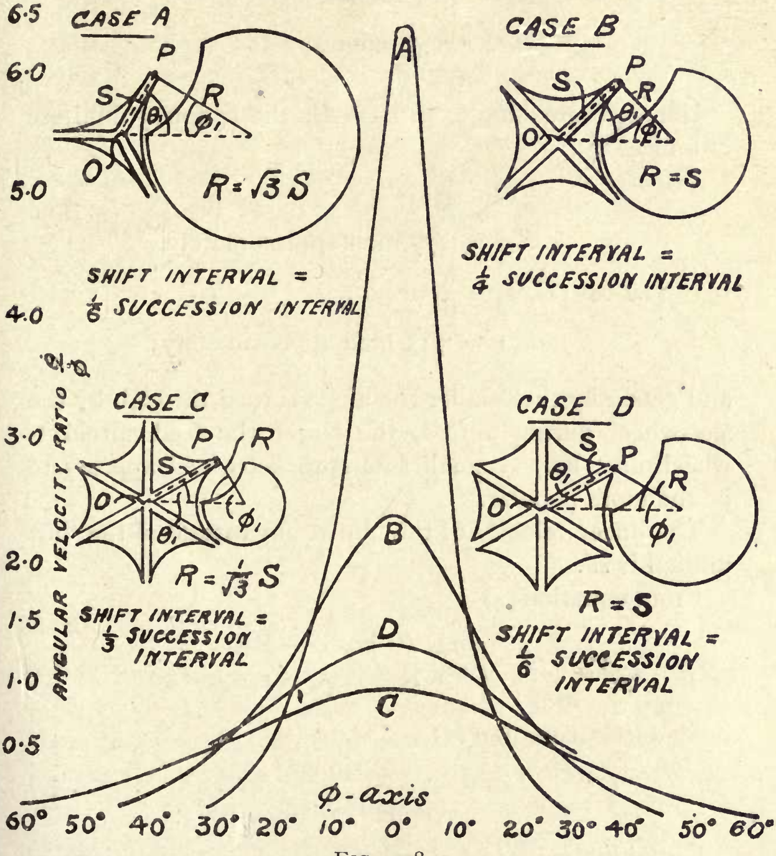

FIG. 118.

this motion of the slot-wheel and partly by the radius of the feed sprocket-wheel, which itself is determined by the size and motion of the slot-wheel.

Let $2r$ = the diameter of the feed sprocket-wheel, which is on the axis of the slot-wheel or geared therewith; then,

since the linear feed of the film through the gate, whatever the feed-motion, is just a picture length, we have—

$$r \times 2\theta_1 = \text{linear feed of film}$$
$$= \tfrac{3}{4} \text{ inches.}$$
$$i.e., \; r = \frac{3}{8\theta_1} \text{ inches.}$$

Hence, for example, in case B, the ordinary Maltese cross feed

$$\theta_1 = \frac{\pi}{4}, \text{ or } 45^\circ.$$
$$\therefore r = {\cdot}477 \text{ inch approximately.}$$

$$\text{In case C, } \theta_1 = \frac{\pi}{6}, \text{ or } 30^\circ,$$
$$\text{and } r = {\cdot}715 \text{ inch approximately;}$$

and generally the smaller the angle turned through by the slot-wheel during a feed, the larger the feed sprocket-wheel must be. A small feed sprocket-wheel appears to be the more popular.

The linear velocity of the film at any instant of the shift motion is $r\dot{\theta}$.

From equation (4)

$$r\dot{\theta} = \frac{r \, \mathrm{R} \, (\mathrm{C} \cos \phi - \mathrm{R})}{\mathrm{C}^2 + \mathrm{R}^2 - 2 \, \mathrm{C} \, \mathrm{R} \cos \phi} \dot{\phi} \; . \; . \; . \; . \; . \quad (5)$$

Also from equation (1)

$$\tan \theta = \frac{\mathrm{R} \sin \phi}{\mathrm{C} - \mathrm{R} \cos \phi} \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (6)$$

By taking values of θ equal to successive fractions of θ_1, the corresponding values of ϕ are determined geometrically, or from equation (6), and the linear velocity of the film at any instant of its movement, corresponding to the fractions of θ_1, may be represented by another series of curves, A′ B′ C′ D′ (Fig. 118A), for the cases

A, B, C, D respectively, where the height of any curve at any point represents the velocity of the film at the instant of its shift movement corresponding to the position of the point on the axis X X′, representing its travel through the $\frac{3}{4}$-inch shift.

The gradient of the curve at any point is proportional to the acceleration which is enforced upon the film, and thus is proportional to the tension or pulling force on the film. Such curves as these thus serve to indicate the variations in the tension or pull in the film during its motion. It will be seen, for example, in case A, that of

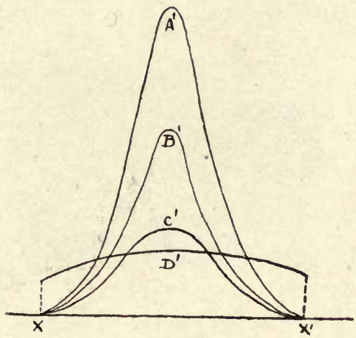

FIG. 118A.

Paul's three-slot feed, that while there is no initial sudden pull, there is a very severe tension or pull on the film corresponding to the steep part of the curve A′, whereas in case D, in which the pin does not enter the slot radially, there is a sudden pull on the film at the start; but the strain on the film, represented by the much flatter curve D′ during the actual shift motion of the film, is comparatively small.

Notwithstanding the simplicity and utility of such mechanism, the Maltese cross as a driving mechanism has had a fluctuating popularity. There is inevitably tremendous wear on the parts, and as the length of the

picture films increased, the problem of lubrication and of preventing the wearing parts becoming unduly heated became a serious consideration. The use of roller-pins considerably reduces the friction, and the use of an oil bath, suggested by Wrench in 1907, secures a minimum of friction. Certainly *post hoc*, if not *propter hoc*, the popularity of the Maltese cross mechanism revived after the introduction of the oil bath. Fig. 119 illustrates the oil bath as used in Butcher's "Silent Empire."

If the number of inventions is any guide, there is still room for improvement in this type of mechanism. A very brief glance must, however, suffice.

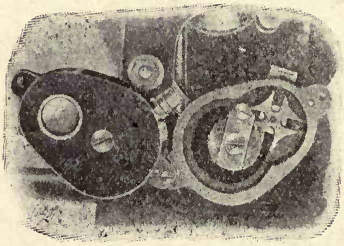

FIG. 119.

Feed-Steadying Devices.—In constructions so far noticed the shaped ends N (Fig. 113) of the cross engage the surfaces of the pin-wheel to steady the feed sprocket during the stationary period of the film in the gate. The Maltese cross itself thus does the double duty of feeding and steadying, and the steadying surface is limited by the size of the cross. It has recently been proposed to fit an additional cross, without any slots, adjacent to the Maltese cross. This enables a locking surface of much greater length to be used for steadying the film while stationary, and also relieves the Maltese cross of half its work. Fig. 120 illustrates the two crosses, M M′, as used on one of Kamm's projectors. In another arrangement

(Fig. 120A) by Guilbert of Paris, the Maltese cross wheel is made as a solid casting, with the slots S recessed in the face. A second casting includes the pin and the steadying

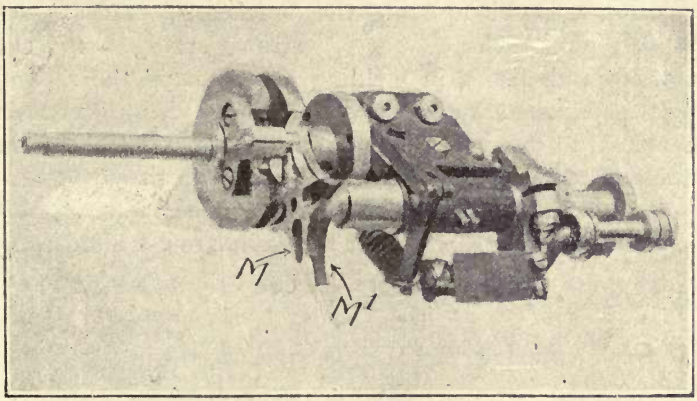

FIG. 120.

surface engaging the shaped periphery N of the rear part of the Maltese cross casting. In another method by Blair (Fig. 121), the pin-wheel 20 carries a cam groove, 21, by means of which a spring-controlled locking lever,

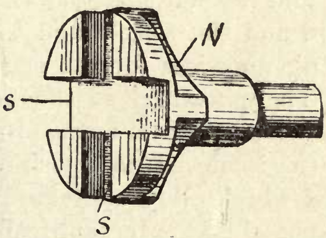

FIG. 120A.

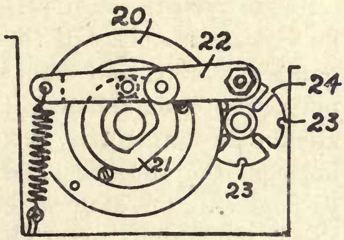

FIG. 121.

22, is moved into and out of engagement with shallow notches, 23, in the Maltese cross wheel, which are interspaced between the feed slots, 24, engaged by the pinwheel. Another feed motion by Mr. Kamm is designed

with a view to taking up any shock where the pin does not enter the slot radially. The pin 1 (Fig. 122) is carried on a disc, 2, resiliently mounted between two discs, 3, 3^a, on the driving-shaft. The Maltese cross bearing 4 is pivoted on the bracket 7, carrying the bearing-pin of the disc 3. A strong spring holds the cross 5 and disc 3 in yielding contact, and the separation is adjusted by a screw, 12. This yielding contact enables the cross and locking-disc 3^a to separate in the event of any grit or dirt getting in between them.

Devices for Rapid Shifts and Long Stationary Intervals.—We have already seen that it is possible to get almost any

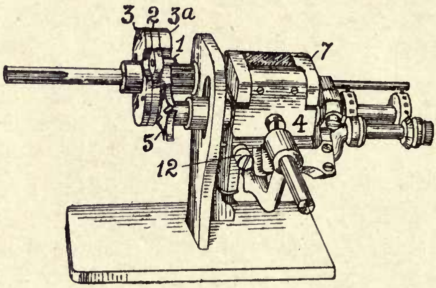

FIG. 122.

ratio between the shift period and the stationary interval by varying the sizes of the pin and slot-wheels, and the number of pins and slots. Other devices for the same purpose are as follow: (1) The pin-wheel is slidable along the rotating axis, and by means of a cam mechanism adjacent the pin-wheel the latter is moved into position to advance the Maltese cross wheel every alternate or third revolution. (2) The pin-wheel is eccentrically mounted on a second wheel, and by the additional rotary motion thereby obtained, the shift movement is correspondingly accelerated. (3) The pin-wheel actuating the Maltese cross attached to the feed sprocket-wheel is itself actuated from a second Maltese cross. The actual shift is therefore accomplished during a fraction only of

the shift period of this second Maltese cross, which is driven from the main driving-gear.

2 (*a* [2]). *Film moved intermittently by a Sprocket-Roller through Interaction of a Wheel or Pin-Teeth with a Worm or Cam.*

The earliest example of this class of mechanism, illustrated in Fig. 123, was designed by Petit in 1895 for a camera, and at first sight closely resembles Edison's device shown in Figs. 78 and 79. The latter was, how-

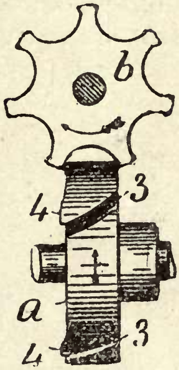

FIG. 123.

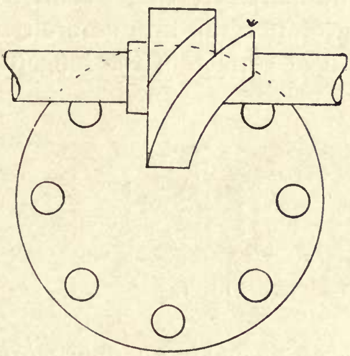
FIG. 124.

ever, purely an escapement mechanism; the toothed wheel always had power applied to it, but could not turn because it was locked, and therefore its driving-pulley slipped. When a slot arrived in place, the tooth escaped straight through it. The interaction of the wheels, however, supplied no power. In Petit's arrangement, on the contrary, the slots are not straight. A star-wheel, *b*, co-acts with a rotated wheel, *a*, having a series of slanting slots, 3. As a slot, 3, approaches the wheel *b*, a slight protuberance, 4, draws a tooth into the slot, which then forces the tooth through to the other side of the wheel, *a*, thus rotating the star-wheel and the film-sprocket attached

to it. The wheel *a* also steadies the wheel *b* between the shifts. The protuberances 4 may be replaced by a kind of hook, as shown in Fig. 124, which draws the pin into the slot. A modification of this same movement is shown in Fig. 125, where a solid "snail" is employed. In this case the star-wheel, instead of being forced round through an inclined groove, is caused to follow an inclined surface, which acts somewhat as an escapement. The star-wheel is not directly attached to the driving axle A, but a spring is interposed, and one of the rollers on the end of the arm is therefore always pressing against the edge of the continually revolving "snail" S. For three-quarters of a revolution this arm naturally remains still, but when the inclined surface of the long tooth comes round, the arm

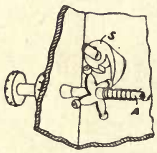

FIG. 125.

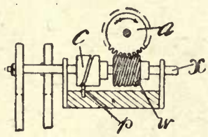

FIG. 126.

follows it, making a quarter revolution, and turning the sprocket-wheel to the same extent. So soon as the arm escapes from the tooth the next arm finds itself steadied against the regular surface of the "snail." A form of snail motion was used very early by Wheatstone as a motive device, whilst the earliest intermittent motions, such as the Choreutoscope and Brown's apparatus of 1869 (see Fig. 48), employed pegs acting on slots placed either around the edge of a disc or along a rack.

Another early suggestion was to use a worm (*w*, Fig. 126) to drive a toothed wheel, *a*, connected to the sprocket-wheel engaging the film. If the worm were fixed, the film would be continuously driven, but the worm is mounted on a sliding axis, *x*, and is moved backwards

and forwards on this axis by a stationary pin, *p*, and cam, *c*. Thus at one time the wheel *a* remains stationary, the worm, so to speak, screwing itself on the wheel; but when the axle travels back, not only does the worm act in its proper manner, but in addition drags the wheel round, thus giving a quick rotation of the sprocket. A modified form of worm action consists in dispensing with the cam *c* and cutting away part of the thread, so that the wheel *a* and sprocket is only rotated when the worm is in engagement therewith. This, however, provides no steadying means for the sprocket-wheel during the stationary interval of the film. This steadying action will be supplied if, instead of cutting away part of the worm, the threads on this part are modified so as to have no turning

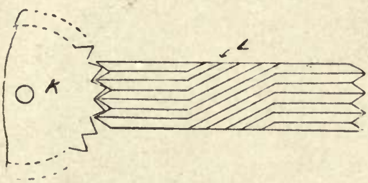

FIG. 127.

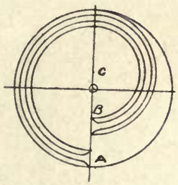

FIG. 128.

action on the wheel. We then get what is, to all intents and purposes, the "drunken screw." The straight grooves of the screw L (Fig. 127) keep the wheel K stationary, and the inclined grooves feed it forward. If the screw is reduced to one thread, we obtain a helical cam, a form of drive which was used in a machine known as the "Rosenberg" cinematograph (patent 16,080, 1896).

Another early method utilized a cam slot, AB (Fig. 128), on the face of a driven disc, G, which is placed adjacent to a pin-wheel, the pins of which stand out from the wheel. Part of the cam is circular. The cam engages a pin at the end A, and the pin-wheel is held stationary while the pin is in the circular portion, but is advanced to the position B by the other part of the slot, thereby rotating

the pin-wheel and the film-sprocket attached thereto. As one pin emerges from the end B, the next pin is in position to enter the end A.

It is somewhat surprising that this type of feed mechanism in which a cam surface or worm is utilized to drive the film sprocket-wheel intermittently has not been more extensively used. The shapes of the cams,

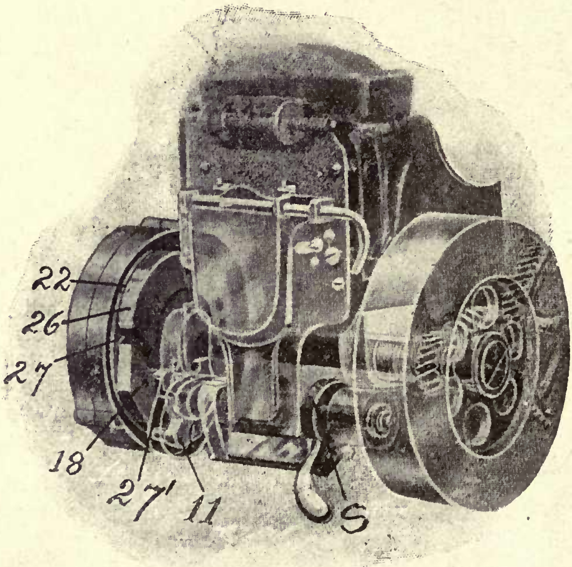

FIG. 129.

slots, or worms, can be modified to give almost any ratio between the stationary and shift periods of the film, and to start the film for the shifts without any jerk. That this type of feed mechanism has very great possibilities for giving a quick, steady feed is well exemplified by the mechanism now used in the "Power" machine. To the sprocket-wheel S (Figs. 129, 130), feeding the film, is attached a star pin-wheel with four pins, 1, 2, 3, 4.

The driving member 22 has a diamond shape cam, 18, separated from the locking ring 26 by two slots, 27, 27′. As the driving member is rotated from the position shown in Fig. 130, the outer part of the cam 18 moves the pin 4, and starts the rotation of the pin-wheel, rotating it just sufficiently to shift the pins 1 and 3 into the slots 27, 27′ respectively. The cam 18 is shaped so as to start the pin-wheel with a gradual motion, and the slots 27, 27′ carry the pin-wheel through a quarter of a revolution. The ends of the slots at which the pins emerge are rounded, so that the pins are moved out of the slots without any jerk, and the pins 2 and 3 are left against the

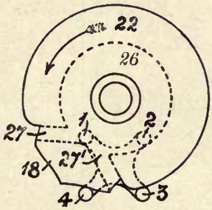

FIG. 130.

inner circular surface of the locking-ring 26, and the pins 1 and 4 against the outer surface. The pin-wheel is thus held very steady until the cam again comes into action to move the next pin, 4.

2 (*a* [3]). *Film moved intermittently by raising and lowering the Sprocket-Rollers.*

If the sprocket-roller below the gate maintains a fixed position, and is rotating continuously, it will, of course, continue to draw down the film. If, however, it is mounted, as shown in Fig. 131, the action on the film may be rendered intermittent, although the sprocket-wheel does not cease revolving. The sprocket-wheel S is mounted eccentrically on a disc, D, the revolution of which alternately raises and lowers the sprocket-wheel,

This latter receives a rotary motion of its own through epicyclic gearing. The two movements are so proportioned that the roller rises along the film at the same rate as the sprocket-teeth rotate, and the wheel itself merely travels up the film. On the downward motion it not only rolls the film down in the ordinary way, but also superadds a drawing action due to its fall. This device, so similar to Dameny's unworkable eccentric bobbin, was

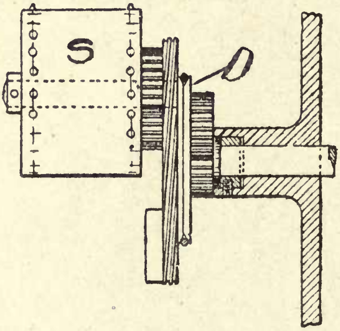

FIG. 131.

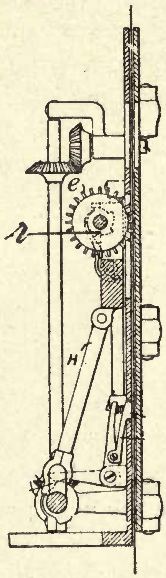

FIG. 132.

employed in the Prestwich camera, and serves as a good example of the manner in which an ineffective motion may be transformed into a thoroughly effective and reliable instrument by careful mechanical treatment. The sprocket-roller, while receiving a motion of its own, may be raised by a crank instead of by a direct eccentric motion applied to its axle. If, however, the sprocket-wheel does not receive a motion of its own, this movement

forms the transition stage between a rising sprocket and claw motion. The wheel *e*, in Fig. 132, rolls upwards along the film, but is prevented from rotating in the reverse direction by a ratchet, *r*. On the down-stroke of the crank-arm H the wheel becomes fixed, and acts exactly as a claw by drawing the film down.

2 (*a* [4]). *Film moved intermittently by a Sprocket-Roller and Ratchet Gearing.*

The first use of a ratchet-gear appears to have been in Heyl's 1870 machine (see Fig. 49), but this apparatus was of very primitive type, a separate hand-pressure being required for every movement of the disc. In Fig. 133 the

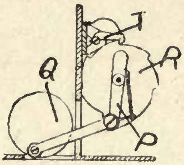

FIG. 133.

ratchet-wheel R is on the axis of the sprocket-feed-roller, and is intermittently rotated by a spring pawl, P, and crank rod, reciprocated by an eccentric, Q. A second spring pawl, T, at the top prevents any backward rotation of the ratchet-wheel. In another form (Fig. 134), the driving pawl P is on a second disc, loosely mounted on the same axis as the rachet R, and is reciprocated by a crank and eccentric, C. The retaining pawl T not only prevents backward rotation of the ratchet R, but engages notches therein and locks it, being raised just before the pawl feeds the rachet by the pin N. In another type of construction (Fig. 135), the ratchet does not serve as a motive device, but only as an escapement. The sprocket-wheel attached to the ratchet has a hollow axle, through which passes a spindle carrying a cam plate, N, in

frictional contact with the ratchet-wheel. Each time the cam raises the retaining pawl T, the ratchet and

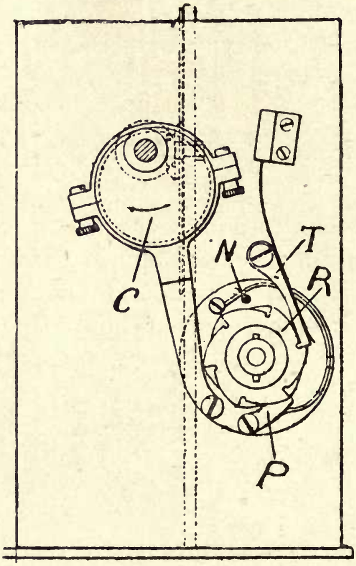

FIG. 134.

sprocket-wheel are therefore fed forward. This frictional drive, however, is not necessary, as the sprocket-wheel

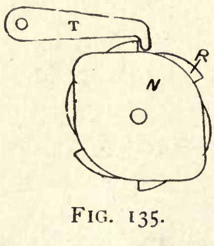

FIG. 135.

and ratchet may each be driven by separate power, such as a contained spring. The cam disc may take the form of a duplicate ratchet-wheel, having teeth set the other

way to act as cams. The retaining pawl will then be lifted as many times in a revolution as there are teeth on the ratchet-wheels.

2 (*b*). *Film moved intermittently by the Periodic Grip of Two Rollers.*

Two very early methods of obtaining an intermittent motion from continuously rotating rollers were suggested by Evans in 1890. One suggestion was that rollers might be allowed to roll along the film for a time, thus leaving it stationary, and then be drawn back as shown in Fig. 70. Or the rollers might periodically be held apart and only

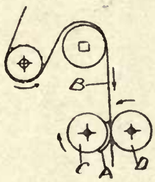

FIG. 136.

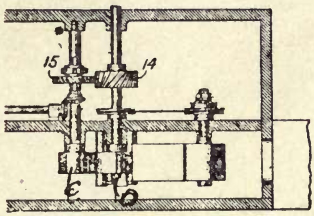

FIG. 137.

permitted to grip the film for a sufficient time to draw a picture-length down. A simplification of this method consists in making a part (Fig. 136) of one or both rollers, C D, with a segmental piece, A, of larger diameter, these segmental pieces forming the gripping surfaces intermittently gripping the film B, and drawing it down a picture-length on each rotation of the rollers. The length of film fed forward at each step can be regulated by varying the relative position of the gripping surfaces. This can be done by gearing the rollers C D together by skew-wheels 14, 15 (Fig. 137), and longitudinally adjusting one or other of these wheels. In lieu of shaping the gripping-rollers themselves or attaching sections of felt or the like, the gripping portion may

comprise an adjustable pad, P, as shown in Fig. 138, which illustrates the feed used in one of the latest Maltheser machines. There is no apparent reason why this type of feed should not have been used more extensively. It would not be necessary to perforate the films, which in itself would effect a considerable saving. The grip could be confined to the edges of the film, thereby

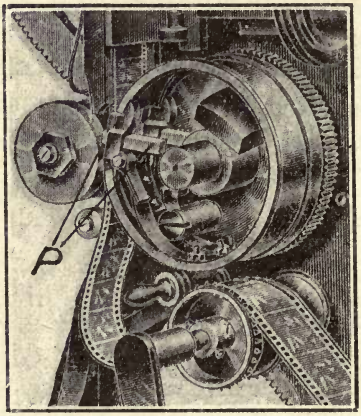

FIG. 138.

saving the picture surface of the film, and the adjustment of the feed is easily obtained by some such method as above described.

2 (*c* [1]). *Film moved intermittently by Spring Teeth.*

The spring fork used by Gray in 1895 (Figs. 88 and 89) was the forerunner of this type of movement. In some degrees, also, the action of the sprocket-wheel in Fig. 132 resembles the spring-tooth action. Fig. 139 illustrates another example. H and *d* are two similar spring-frames, with teeth engaging the perforations in the film. The frame H is fixed, while the frame *d* is reciprocated on a bearing, G. The slope of the pins is such that on the

downward motion of the frame *d* the pins d^2 carry the film down a picture-length, and at the end of the stroke a yielding part, d^1, of the frame engages behind a ledge, *g*, and presses the pins d^2 into the perforations to steady the film just on the completion of its movement. On the upward motion of the frame *d* the pins d^2 spring out of

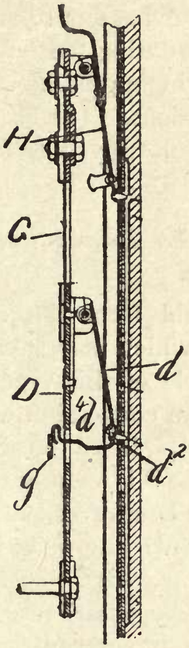

FIG. 139.

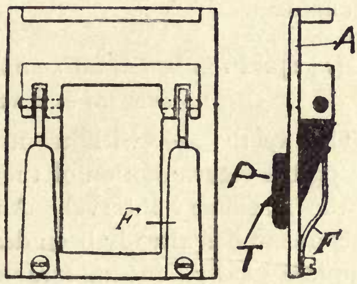

FIG. 140.

the perforations and ride over the edges of the film, while the spring-teeth on the frame H engage perforations to prevent the film being dragged backwards. In another similar arrangement of this description (Fig. 140), a reciprocating frame, A, carries two pivoted pawls, P, with wedge-shaped teeth, T, which are lightly pressed against the film by springs, F. On the upward motion of

the frame the upper slanting edges of the teeth drag over the film; on the downward motion, the spring presses the teeth into perforations, and the film being in contact with the straight under edge of the teeth, the latter have no tendency to leave the perforations.

The obvious drawback to this type of feed is the action of the spring teeth on the edges of the film on its upward stroke. One method of avoiding the drawback is to shift the film out of the path of the feed-pins during the return motion. This is done by means of a swinging-plate intermittently operated by a cam or equivalent. The drawback is, however, better avoided by the next type of feed mechanism.

2 (*c* [2]). *Film moved intermittently by Teeth mechanically inserted and withdrawn.*

The teeth are withdrawn and held from the film during the return motion of the teeth, which corresponds to the stationary interval. An example of this type of mechanism has already been described in connection with Lumière's early Cinématographe (p. 95). It will be seen, on referring to Fig. 93, that the pin-frame B is reciprocated upwards and downwards by a revolving cam or eccentric, and that the pins are alternately withdrawn and moved to engage the perforations in the film by wedges on the rotating arms C. In another camera by Blair, near in point of date to Lumière's, the film is intermittently moved by a roller, I, shaped as shown in Fig. 141. As an alternative, instead of shaping the roller I, a cylindrical roller, R (Fig. 142), is fitted with projecting pins, Q, which have an axial motion in the cylinder. The pins are periodically protruded to feed the film, and retracted on the return motion by means of the T-shaped head I of each pin taking into a cam groove in a plate, O, mounted at the side of the cylinder. It will thus be seen that for this type of feed the motion required for the pins is

substantially the path of the letter **D**, where the straight part of the letter represents the feed motion, and the curved part the return motion of the pins. Another way of giving the pins such motion is by pivoting an arm carrying the pins to a slide moved up and down by a cam or eccentric, such, for example, as in Lumière's camera, and by providing a **D**-shaped cam groove for the **T**-shaped

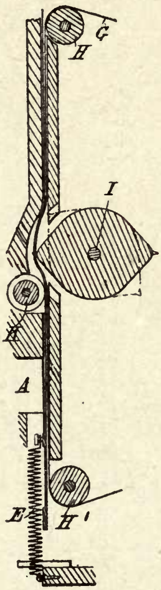

FIG. 141.

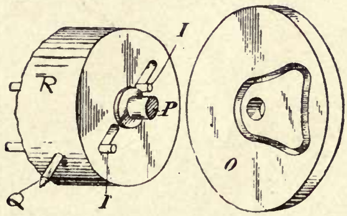

FIG. 142.

ends, such as I, Fig. 142, on the pin frame, which may have roller pins to minimize friction.

Another early mechanism for obtaining this **D**-path motion of the claws is illustrated diagrammatically in Fig. 143A. The claw A is at the end of the rod ABC. The points M and O are fixed centres for the rods MB, OC. The claws move through the vertical feed path during the motion of the arm OC from R to S, and through

the return path during the motion of the arm OC from S to R. The feed and return motions are with such mechanism performed during the same interval of time—namely, the time of a half-revolution of the arm OC. If it is required to obtain a quicker vertical feed motion, relatively to the return motion, a variable motion must be given either to the point B or to the point C. In one ingenious device (Fig. 143B) the pin-frame 17 receives

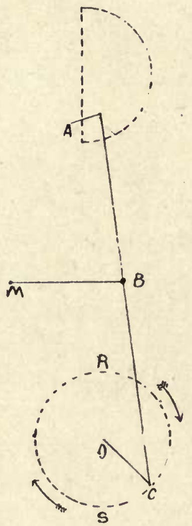

FIG. 143A.

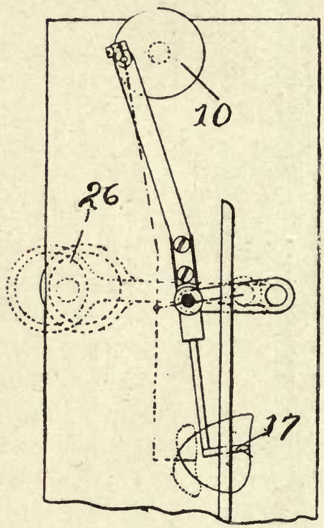

FIG. 143B.

its up and down motion from the eccentric disc 10, and its to-and-fro motion from a second eccentric, 26. If the eccentric 26 makes a half-revolution to each revolution of the eccentric 10, the pins will first describe the path shown in full lines, and then retreat along the dotted continuation, thus greatly increasing the period during which the film rests relatively to the shift period.

In another recent mechanism devised by Mr. Proszynski (Fig. 143C) for the same object, the link OC is mounted

on the same shaft as a slotted arm, S. The variable rotation is given by the pin P, of an eccentric ring, E, which rotates on the fixed disc F, and describes the dotted path D as the driving-wheel V is rotated about the centre Q. The pin P is steadied in the arm S, and in

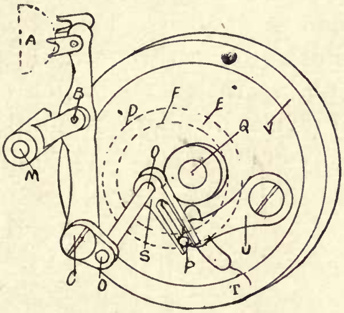

FIG. 143C.

a slot, T, in the disc V, by the arm U, pivoted on the disc V. In this mechanism the claws are adapted to act along the gate slide so as to steady the film for projection when the tractive force ceases.

If the link MB, in Fig 143A, is replaced by a stationary slot, F, as in Fig. 144, to guide the pin E on the feed-

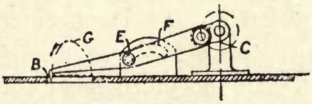

FIG. 144.

arms, the combined action of the rotating crank C and the slot F will force the feed-pins B to describe the **D**-curve G. This mechanism is used in Messrs. Williamson's cameras and perforators.

In another early method, and the forerunner of the modern Kineto machine, a cam single groove is used to

obtain both the motions of the feed-pins. The feed-pins are pressed back by a spring, *f* (Fig. 145), and the stud *e* is consequently driven right home into the cam groove of the revolving cylinder *a*. As the cylinder turns, the pin frame will be drawn up and down, and the groove being made to vary in depth, the pins are thrown more forward at one time than at another. The forward pressure is arranged to coincide with the downward course of the pins, and *vice versa*. In a modification of this feed the cam groove is of regular depth, to obtain the up-and-down motion, and the to-and-fro motion of the pins is obtained

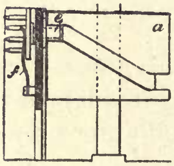

FIG. 145.

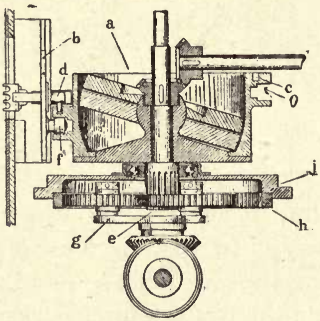

FIG. 146.

by an eccentric, such as 26, in Fig. 143B. Alternatively, again, the to-and-fro motion is obtained by a rack and pinion movement, operated from a second cam groove in the cylinder *a*. In the more recent device (Fig. 146), used in the Kineto projector, one of the latest machines with the pin-feed, two cam grooves are used in the cylinder *a*. One groove, *o*, in the outer periphery engages a roller pin, *f*, and imparts the vertical movement to the feed-slide *b*; the other groove, *c*, in the top face of the first groove, *o*, engages the pin *d* to control the position of the pin-frame relatively to the film. Two balancing discs in the centre of the cylinder *a* are

arranged to exactly counterbalance the difference in the mass of the cam drum, and counteract any deflecting strain on the bearings. The cylinder is driven by means of a fixed ring, *h*, cut with internal teeth, and three planet wheels on the spider *g*, gearing both with the ring *h* and driving the central pinion *e* on the axis of the cylinder *a*.

The examples given will sufficiently indicate the ingenuity which has been spent on this type of feed. It is not much used for projectors, but is very extensively used for feeding the film in perforating and printing machines. The action of the pins serve in the latter to feed the positive film along with the negative film, both films being thereby fed at exactly the same rate.

The motion of the film during a feed by the claws can be represented by curves similar to those shown in Fig. 118A. In the case of the claw-feed the claws always enter and leave the perforations when stationary, and the curve will always start from X and finish at X′. The quicker shift movements are represented by steep curves, and the consequent strain on the film is correspondingly great. The slower shift movements are represented by flatter curves, and the consequent strain on the film is correspondingly less.

2 (*d* [1]). *Film moved intermittently by the Pressure of a Revolving Eccentric.*

The original so-called dog-motion, invented by Demeny, is shown in Fig. 82. The amount of film fed forward can be adjusted by adjustably mounting the eccentric roller R along a slot in the revolving disc D (Fig. 147). If the film passes between two gripping rollers, such as A, B, which continually rotate, and thereby continually put tension on the film, it is necessary to have pressure pads, P, at the gate to hold the film stationary when the dog is not acting on the film. It is more usual, however, to use a sprocket-roller in lieu of the rollers A, B, for the purpose of taking

up the loop intermittently fed by the dog. The film is not then under continuous tension. A very recent dog feed-motion used on one of Kamm's machines is illustrated in Fig. 148. The principle is similar to the cam action of a sewing machine. A pin, P, on a rotating disc, O, travels in the slot S of a pivoted arm, R, carrying the roller M,

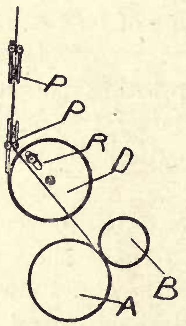

FIG. 147.

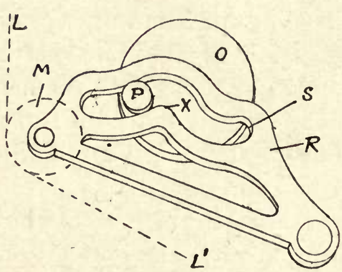

FIG. 148.

actuating the film LL′. In the position shown, the roller M is just about to feed the film, and a very quick feed is obtained as the pin P rides over the hump X in the slot S.

2 (*d* [2]). *Film moved intermittently by a Reciprocated Arm.*

The roller which strikes the film need not have a rotary action, though that is, perhaps, the best form, there being no dead point. Evans, in 1890, showed a double tilting-arm applied to this purpose (see Figs. 71 and 72), while Varley almost simultaneously invented a cam-reciprocated arm. In another early arrangement, shown in Figs. 74, 97, the feed-roller acted under the influence of a spring-arm, when the film was released from clamps. Blair, in 1896, suggested a rocking arm with a roller, Q^2 (Fig. 149), at one end, which is oscillated by an eccentric, E^5, on the driving-shaft E. By another eccentric, E^2, set at right-

angles to E^5, pins, N, are intermittently engaged with the film to hold it steady during the stationary interval. In a further development of this type of motion, a pair of

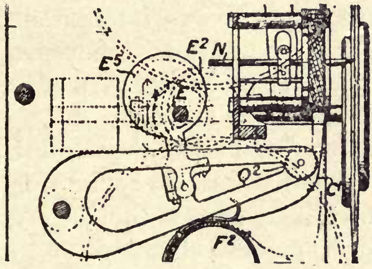

FIG. 149.

vibrating levers, P, P′ (Fig. 150), with rollers at their ends, are linked together and worked up and down by a cam, T, on the driving-shaft *g*. A spring gripper, t^2, actuated by

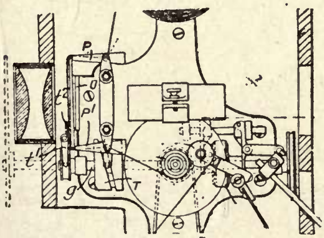

FIG. 150.

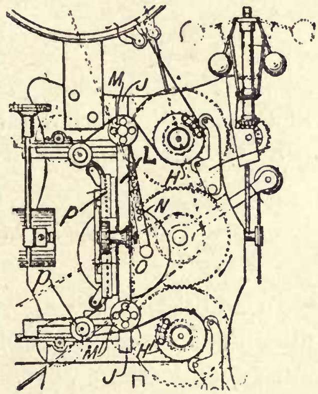

FIG. 151.

a cam, t', holds the film against the gate U during the upward motion of the levers. In all such cases the feed action takes place over an arc. Another device suggested by Blair, in 1896, consisted of a rise-and-fall shutter, with

rollers at the top and bottom, and vertically reciprocated by a crank. The film is clamped during the upward motion of the shutter, and is fed forward on the downward motion. In another machine, a similar vertical slide, not forming the shutter, was intermittently raised by a rotating cam, and the return-feed movement effected by a spring. In a later machine (Fig. 151), of the same kind by Hughes, the feed-rollers M, M′ are mounted on a frame, L, which is reciprocated along the vertical guide bar J by a crank disc, O, and adjustable connecting rod, N. The feed sprockets H, H′ are continuously driven, and the film passes over guide-rollers, *p*, so that the rollers M, M′ act at right angles to the moving film. In the

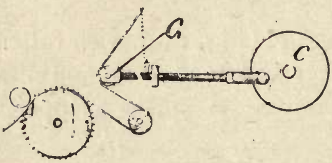

FIG. 152.

most recent machine of the same maker, the Bio-Pictorescope, a horizontally moving "piston plunger," G (Fig. 152), is reciprocated by a crank, C (see also Fig. 199).

2 (*e*). *Film moved intermittently by Other Means than the Above.*

In addition to the above methods, there are one or two miscellaneous methods of moving the film, which are at any rate interesting, even if not in practical use. In one such, Fig. 153, suggested in 1896, two blocks, M′, are driven forward intermittently to grip the edges of the film against a plate on the other side. The gripping-blocks and plate then sink together, carrying the film with them. Flexible guards, M^8, prevent the film buckling, and when the pressure of the grippers ceases, a brake pad, Q, comes

into action, and clamps the film while the film rises. In another device, Fig. 154, two plates, A, are formed with internal ribs, C, which are concentric with the plates for the greater portion of their length, and then curl inwards so that their ends are separated by the length of a picture. The film D is notched along the edges, and the notches engage the ribs. When the circular portion of the ribs engage the film, it remains stationary. When the

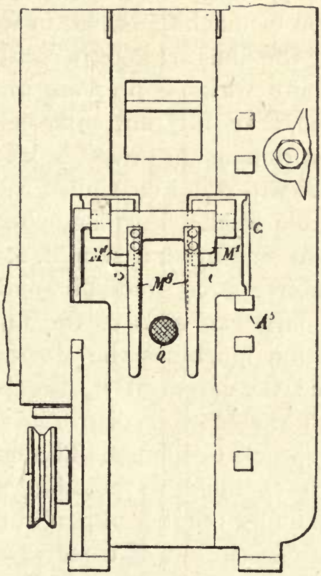

FIG. 153.

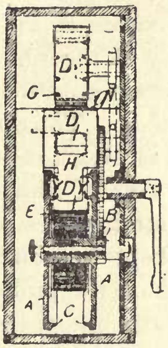

FIG. 154.

inwardly curved part comes round, the film is drawn down. The action is similar to the action of the cam slots, illustrated in Fig. 128, on the pin-wheel in engagement therewith.

If the reader has had the patience to follow out the preceding rough outline of the mechanical methods for

obtaining intermittence, he will probably agree that there appears to be little room for the introduction of many new principles. Yet these descriptions have, in many cases, been only outline; the illustrations but diagrams. The extreme accuracy demanded in all these motions, together with the necessity of moving the film at a high speed, and yet stopping and starting it many times a second, renders a large number of mechanical refinements necessary. If it be permissible to express a personal opinion, it may be suggested that the best form of machine is that in which all parts (naturally excepting the film) are kept in continual rotation, thus minimizing any variable pressure on the elements of the apparatus. If intermittently acting parts are employed, the workmanship must be of the best, and the material such as will stand continued friction and shock without perceptible wear. Further, whatever the nature of the mechanism employed, it should, for the safety of the film, apply tractive force gradually, and distribute that force over as large an area of the film as possible. Thus, in dog-motion machines the size of the dog is of great importance; the larger it is, the larger the area of film over which the blow is distributed. If the strain takes place on a sprocket-roller, the film should be kept in contact with it as much as possible, so as to share the pull over a maximum number of perforations. To attempt the systematic description of these arrangements would be a hopeless task, as they are so bound up with the build of the machine in which they appear. Some have already been incidentally noticed, such as the interposition of a spring as used in Greene and Evans' early machine, which may be used to obtain variations in the driving power; and the use of fingers or pins for intermittently engaging the film to hold it steady in the gate. Other refinements will also incidentally appear in considering various designs of machines in subsequent chapters.

CHAPTER V

FILMS, THEIR PRODUCTION AND TREATMENT

Celluloid and non-flam films—Perforation—Cameras and accessories—Developing the negative—Printing the positive—Developing the positive—Retouching, colouring, and protecting the film—Joining and repairing films—Cleaning and renovating films.

A FILM for projecting a Living Picture is nothing more, after all, than a multiple lantern slide ; and its production is therefore in all respects similar, with the exception of those manipulative details necessitated by its peculiar form, and the special care required to secure absolute registration of each picture with its predecessor. In order to describe all such devices connected with the treatment of films, it may be assumed that whatever is good enough for a lantern slide is the correct thing in the treatment for a Living Picture film, only probably not good enough. After considering the nature of the film itself, we shall have to consider the various processes and manipulations to which a film is subjected in the course of its career.

CELLULOID AND NON-FLAM FILMS.

A film should have certain properties to meet the exacting demands made upon it. It should be strong, supple, transparent, homogeneous, unaffected by atmospheric conditions and changes, and, last but not least, it should be non-inflammable. By one of Nature's contradictions, celluloid, the substance most extensively used for films, has ali the qualities required except the last, being extremely inflammable.

Celluloid as an article of manufacture was invented at Newark by two brothers of the name of Hyatt, in 1869, but at the time was designed merely for the production of solid objects. It was not till the beginning of 1888 that sheets were available for photographic purposes, and even then much remained to be accomplished in order that a sensitive emulsion might be supported evenly and without deterioration. The Blair Company seem to have first supplied films, and it was from them that both Edison and Acres in the first instance obtained their supplies. A patent was applied for in America in 1887 by a Rev. H. Goodwin for celluloid films in rolls, with a non-curling backing, but this patent was not granted till 1898. It is strange that the then comparatively small subject of Living Pictures should have afforded two instances of patents so long delayed. In the meantime the Eastman Company of America applied and obtained a patent for a similar film, and put the films on the market. Messrs. Lumière also started to manufacture, and made their own films, a fact which was probably the origin of the lack of uniformity in gauge which prevailed until comparatively recently.

The manufacture of celluloid at the present time forms a very important branch of what is known as the nitro-cellulose industry. The raw material from which celluloid is made is cellulose, which is the principal constituent of such materials as paper, cotton, cotton-waste, hemp, and flax. The cellulose has first to be converted into nitro-cellulose, which is a chemical name for what is more commonly known as pyroxylin, or gun-cotton. This conversion is effected by treating the cellulose with a strong mixture of nitric and sulphuric acids, and the pulpy mass thereby obtained is bleached. The bleached nitro-cellulose is then thoroughly washed to remove all free acid. The presence of any acids give rise to by-products which very rapidly decompose, and thereby

produce very inferior films, as well as being the cause of accidents arising from such decomposition. Celluloid is a solution of this nitro-cellulose in a solvent, containing camphor, alcohol, ether, and sometimes amyl-acetate and amyl-alcohol. It must be stated here that nearly all manufacturing companies have their secret compositions, which are deemed more valuable as such than if disclosed to the world through the medium of the Patent Office, even for a possible monopoly in them for a period of fourteen years.

To obtain the celluloid in the form of thin films, the solution is run out in a continuous manner from a thin wedge-shaped opening on to an endless band having a smooth surface, and forming a temporary support. The thin coating thus obtained becomes hardened in travelling through a drying chamber, which evaporates the solvent. The film is then detached from the surface of the belt, which travels round again under the discharge opening, and the detached film is wound on a reel. In lieu of an endless band, the solution may be poured on the surface of a large cylinder.

The film has next to be cut into the required widths. Practically speaking, there is at the present time only one width used, which is about $1\frac{3}{8}$ inches. This gauge was used by Edison for the Kinetoscope; it was also adopted by Paul in England, and, in spite of many attempts to put films of other gauges on the market, the original Edison gauge has prevailed. The pictures on the film are normally 1 by $\frac{3}{4}$ inch.

Before coating the film with emulsion, it is necessary to coat it with a substratum which will enable the sensitized emulsion to adhere to the film. There are many ways of coating the film. It may be coated, for example, in much the same way as the celluloid solution is coated on the endless band in making the celluloid film. In another method, a roller dipping into the emulsion coats the film directly, or through the medium of an inter-

mediate roller, and the coated film passes through a drying chamber to the reeling spool. The action is essentially the same as the action of the chalking roller of a lawn-tennis marker. It is very necessary that the coatings deposited on the film should be perfectly even and of the requisite thickness. The coatings are, of course, applied in a dark-room.

The one and only drawback to the celluloid film is its inflammability. For some time—and especially after the passing of the Cinematograph Act,* which enforces very stringent regulations for the safety of the public where inflammable films are used—investigators have sought to find an equally serviceable film which will not catch fire so readily, or burn with such inextinguishable fury when alight.

The inflammability of celluloid arises from the two very inflammable ingredients, nitro-cellulose and camphor. Of the several methods which have been tried for obtaining a non-flam film base, the following are the chief: (1) Solutions have been added to the nitro-cellulose-camphor solution which will check combustion, such as solutions of mineral substances, or alternatively substances which will evolve incombustible gases. (2) Camphor has been replaced by less costly substitutes. (3) Nitro-cellulose has been replaced by some other cellulose compound, such as cellulose acetate. (4) Films of gelatin, casein, albumin or other colloid, or a thin layer of celluloid sandwiched between two protective layers of gelatin or other colloid, have been tried.

The first two methods do not seem at present to have yielded satisfactory results for Living Picture films, although products are obtained which are quite serviceable for other commercial purposes. The products are, however, too brittle for Living Picture films. Films made from gelatin and similar substances, or with protective

* See Chapter IX.

coatings of these materials, are unsatisfactory, largely on account of their susceptibility to atmospheric conditions and changes. The promise of the future seems to lie in the use of the third method. Most of the well-known makers of films supply, or have supplied, films made from cellulose-acetate, which are, in the ordinary meaning of the word, non-inflammable. If an Act of Parliament were passed, making the use of non-flam films compulsory, and prescribing a standard flammability test, it is not unlikely that the virtues of such films would be immediately discovered. It is to be feared, however, that the inertia to be overcome before the use of such films becomes anything like extensive is very great.

Perforating the Film.

Perforations and Gauges.—As the prevailing method of driving the film in taking and projecting machines is by means of sprocket-rollers, the next step in the production of a Living Picture film is usually to perforate it. Here, again, as in the case of widths, the standard perforation is that used originally by Edison. There are four perforations (Fig. 155) on either side of each picture, the holes being exactly $\frac{3}{16}$ inch apart, the crossways separation being $1\frac{1}{64}$ inches, just leaving a clear inch for the picture. Lumière endeavoured to substitute one pair of holes to each picture length, but the attempt was not successful. A similar attempt to depart from the standard perforation has recently been made for the Pathescope.

Almost every conceivable shape of perforation has been tried or suggested. The Lumière perforation was circular, but as the feed-sprockets are often square or rectangular, there would, if the film is used in a machine having such sprockets, be a tendency to split the film, as illustrated in Fig. 155A. Lord Kelvin suggested a triangular shape. The rectangular shape used by Edison is modified to

the extent of rounding the sides, leaving, however, at the top and bottom a straight edge for traction purposes, and thereby reducing the risk of rupture to a minimum. The

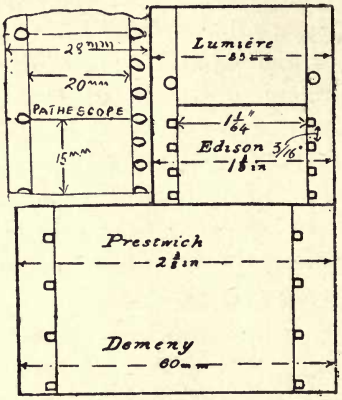

FIG. 155.

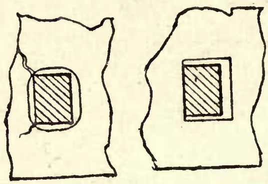

FIG. 155A.

importance of these considerations is heightened when the question of strain on the film is considered. Tension on the film is shared between the perforations actually

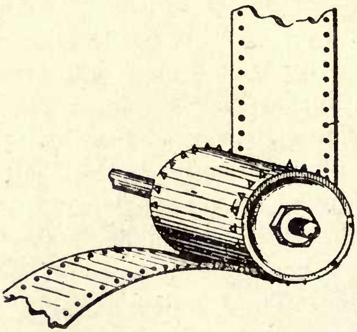

FIG. 156.

engaged with the sprocket-teeth, and it would appear easy to carry the film round the major portion of the sprocket-roller (Fig. 156), in order to subdivide the strain as far as

possible. But this can only be done to a limited extent; for not only do various films differ slightly in gauge, but shrinkage in development, and even atmospheric influences, tend to vary the distance between the perforations. Interchangeable sprocket rollers have been used to suit any special make of film under exhibition, or any film in a shrunk condition. It would seem that shrinkage had much to do with slight differences in perforation gauges, for at first perforating machines were in some instances made to agree with finished films rather than with the original standard perforation, as should have been the case.

It must not be forgotten that in some types of cameras and projectors (for example, certain continuous-motion apparatus, and others in which the film is gripped, not held by teeth) perforations are not necessary, although they are not detrimental if present. Some very extraordinary suggestions have also been made for perforating, such as central eyelets, which would hardly facilitate rolling, and the carrying of perforations across the film between each picture, presumably in order that they might be torn off like postage stamps. Reference may also be made to Fig. 95, wherein a film is shown notched on the edges. The advantages of this system are certainly not obvious.

Perforating Machines.—The first and undoubtedly the most important machine necessary for film-making is the perforator. An accurate perforation is the fundamental basis of a perfect projection—at any rate, where a sprocket feed is used. This demand for accurate perforation has resulted in the production of several machines of marvellous precision. There are broadly two classes of machines: (1) Those in which the film is continuously moving between two cylinders, formed respectively with dies and punches, as illustrated in Fig. 157. This type does not admit of many variations in structure and

working. It was more used in the early days than it is to-day, having given place to the second type. (2) Those in which reciprocating punches are used, the film being

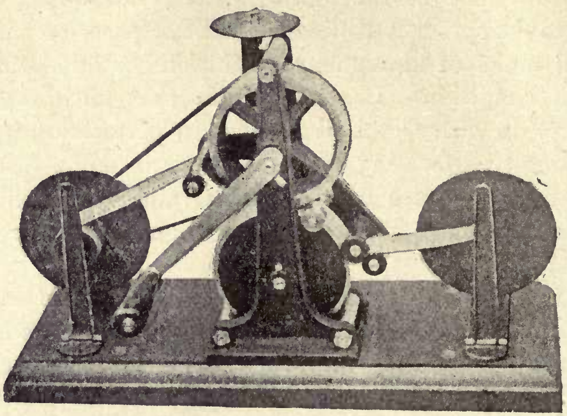

FIG. 157.

fed intermittently, generally by a claw feed. Fig. 158 illustrates Williamson's perforator, which is representative of this type, as well as embodying the fruits of the

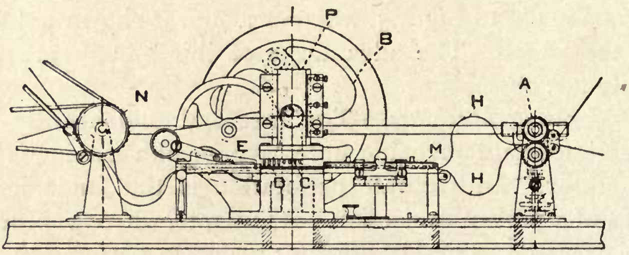

FIG. 158.

long experience of its designer. With this machine two films, face to face, can be perforated together, in order to protect the sensitive surface from getting scratched, which is liable to occur to a greater or less extent when

the films are perforated singly, and also incidentally to double the output. The films are fed by rollers, A, so as to form loops, H, H, before entering the guide channel M. The machine punches four pairs of holes at a time, and, as security for absolutely uniform perforation, the reciprocating slide P, carrying the punches C, carries also a similar set of dowel pins, D, which engage the perforations just previously made before the punches C perforate the next section of film. The film is fed by the claw feed E, which is described in Fig. 144. The sprocket N

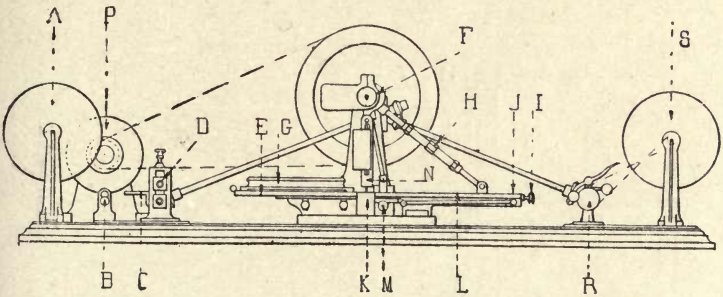

FIG. 159.

A, Film-holder (feed); B, film-guide rollers; C, small channel for feed rolls; D, feed rolls; E, rear guide; F, cams; G, pressure rods; H, regulating nut; I, milled-head screw; J, screw, fixing the claws in the carriage; K, detachable die; L, front guide; M, claws; N, slide, carrying punches; P, motor; R, sprocket wheel; S, rewinder.

is driven from the driving wheel B, and maintains a free loop of perforated film, thereby avoiding any pull on the film during the perforating. In order to keep the perforations very accurately central, the guiding channel M is fitted with two parallel resilient bars, which are linked together in such a manner that, if the width of the film should vary in the slightest degree, the bars will not only remain parallel, but will yield to exactly the same extent from the centre of the channel, at all points along the channel.

In most perforating machines, however, only one pair of holes is punched at a time, as in Debrie's perforator (Fig. 159). There are quite a number of points which arise on the question as to the advisability or otherwise of punching more than one pair of holes at a time, into which it is impossible to enter fully here. There is no apparent fundamental objection in principle, as four pairs of holes can be as accurately punched as a single pair, provided, of course, the punches and dies are accurately

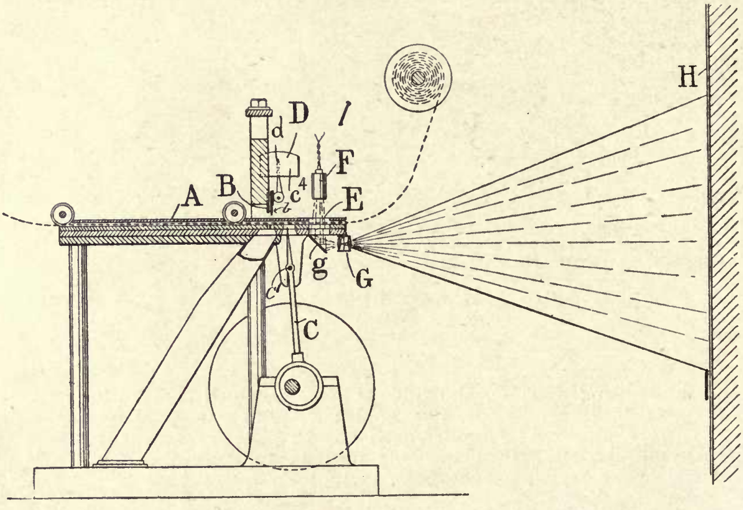

FIG. 160.

spaced. There is certainly a saving as regards output, and the probable cumulative error of spacing will be one quarter of the corresponding error where only a single pair of holes are punched at a time. If anything should happen to one of the four punches or the dies, or one of the punches were to become inaccurately spaced, it is preferable to replace the complete set than to attempt to doctor any single punch, as, if this is not done with extreme accuracy, it might introduce an error in spacing

which would be cumulative along the whole length of the film.

In some machines, again, dowel pins are not used for positioning the film, but an intermittent clamp is used, which comes into operation immediately the film is fed forward, and is released just before the next feed.

The provision of means for adjusting the spacing of the perforations is a very valuable one, and in some cases is a necessity, as will be more fully explained in dealing with the production of the positive film. Debrie's perforator has such adjustment, as also has the Newman and Sinclair perforator. In one form of adjustment the position of the dowel pins *b*, relative to the punch pin B (Fig. 160), is adjusted from an index finger, *d*. In an alternative adjustment designed by Mr. Newman, only

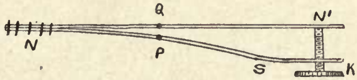

FIG. 160A.

one dowel pin, P (Fig. 160A), is used, which is mounted on a strong arm, S, secured at N to the bar NN′, carrying the punches Q. The position of the dowel pin P is controlled by a micrometer thumb-screw, K, at the opposite end of the spring bar S, and it will be seen that the displacement of the dowel pin P is only a fraction of the displacement of the end of the spring bar S, produced by turning the screw K, and thus an exceedingly fine adjustment can be obtained. An alternative method of adjusting the gauge is to adjust the feed of the film. This may be done, for example, by making the position of the fulcrum C′ (Fig. 160) adjustable along the feed arm C. A further development of this apparatus recently suggested by Mr. Thornton comprises the addition of means for visually inspecting the film, in order that the operator may adjust the gauge as perforation progresses.

This is accomplished by providing an opening, E, in the table, and projecting the picture in the opening on a vertical screen, for which purpose a lamp, F, mirror, *g*, and projecting lens, G, are provided. In this way the film is projected just as in the projector, excepting that it will take four shifts to bring the next picture into full view on the screen. Any tendency in the picture to creep on the screen will thus be noticed, and the perforating adjusted from the handle *d*.

Taking the Negative, and Apparatus therefor.

The Camera.—After perforating the film, the next step is to obtain the negative. Of cameras, the cinematographer, like the ordinary photographer, has a wide choice, and can now have a motor-driven hand camera. Broadly speaking, a camera for Living Pictures is similar to an ordinary roll-film hand camera, but fitted with mechanism for drawing successive portions of the film into the focal plane for exposure at a rapid rate. The previous chapter has recorded the various mechanisms which could be used for this latter purpose, but in practice the only one used is the claw-feed mechanism. The reason for this is that such mechanism gives a very accurate feed, while at the same time it is the least complicated, and can be made lighter than other feed mechanisms. Fig. 161 may be taken as illustrating a typical modern camera. The upper film box A holds the unexposed film, and the lower box B the exposed film. The film is threaded over the upper sprocket C, and through the gate D, which contains a mask limiting the area of the film exposed to the required size—namely 1 inch by $\frac{3}{4}$ inch. The film then passes over a second sprocket, E, into the box B. The arms C′, E′, carry rollers to press the film into engagement with the sprockets C, E, and loops, P, P′, are left on either side

of the gate to prevent any tension of the film while it is in the gate. In front of the gate is the shutter, the simplest form of which consists of an opaque disc from which a sector is cut away. This open part crosses in front of the film during its stationary interval in the gate, and the opaque part masks the film during the shifts. Two shutters relatively adjustable are used when an adjustable exposure is required. The shutter, the upper and lower sprockets C, E, the intermittent feed mechanism, and the take-up spool in the box B, are all driven in

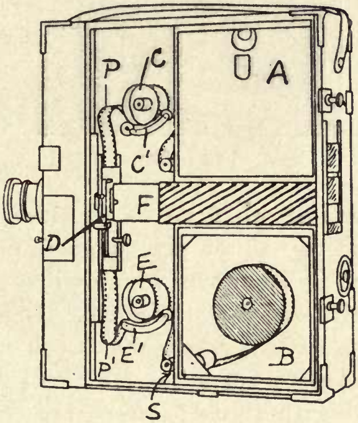

FIG. 16.

unison from the handle turned by the operator. The provision of the focussing tube F, which contains a magnifying glass, enables the film to be accurately focussed by inspection. The lens is fitted in a focussing mount, and can be automatically set for focussing near objects, when focussing by inspection is undesirable. The camera is also fitted with a film punch for registering on the film the termination of any particular exposure, and with dials indicating the amount of film exposed and the amount left.

The spool box is an important accessory for all cameras. To keep them light-tight, the light-trapped slot S, Fig. 161, through which the film enters or leaves the box, is often rendered light-tight by padding the slot with a soft plush material. Now, when a film is rubbed vigorously by soft material of this character, electrical markings are liable to occur. If any dirt or grit should get on to the material,

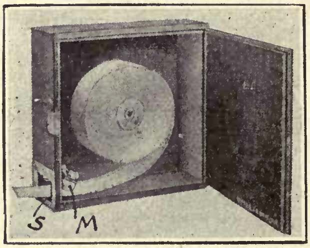

FIG. 161A.

scratches also will be produced on the film. A scratched or marked negative cannot give a good positive, as no method of printing is known which will select the good parts of a negative and reject the bad. It is therefore, at any rate, necessary to periodically brush and clean any soft material used for padding. Fig. 161A illustrates a spool box fitted with a padded mouthpiece, M, which is

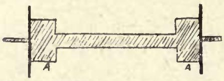

FIG. 161B.

hinged, in order to be accessible for cleaning. It is automatically positioned, and held in the film slot S when the door is closed.

For the same reason also the film, and especially the sensitive surface of the film, should, as far as possible, be prevented from rubbing against any surface during its path through the camera. Where guiding slots or sur-

should prefer a simpler camera is not surprising, and Fig. 165 illustrates a camera noted for an absolute maximum of simplicity consistent with the requirements for efficiency. It will be seen that only one sprocket wheel is used, which does the double duty of drawing the film from supply and feeding it to the take-up spool. A further feature of this camera is that the whole feed mechanism, including the sprocket and claw feed (which

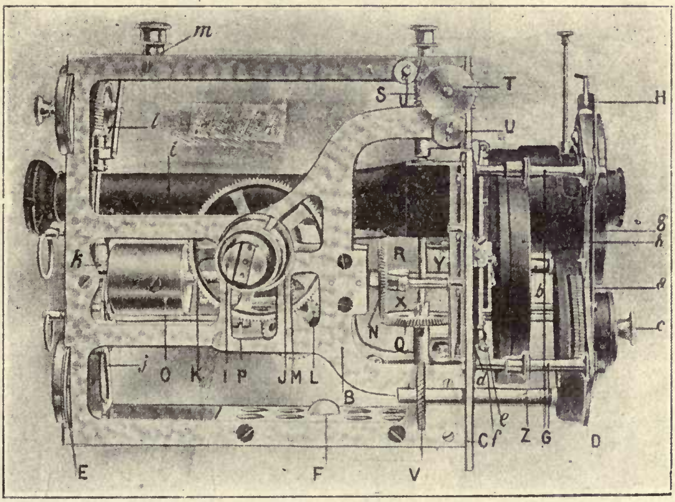

FIG. 164.

of the type illustrated in Fig. 144), is mounted on a tachable bracket screwed on to the camera case.

With these cameras the film is driven by hand or by eparate motor, and the camera must be mounted on a od or other support. The latter method of driving is suitable for studio work where a current is available, impracticable for outdoor and topical work. Many pts have been made to devise a camera with a self-ned motor, which can be held in the hand while the is being taken, just like an ordinary hand camera,

The spool box is an important accessory for all cameras. To keep them light-tight, the light-trapped slot S, Fig. 161, through which the film enters or leaves the box, is often rendered light-tight by padding the slot with a soft plush material. Now, when a film is rubbed vigorously by soft material of this character, electrical markings are liable to occur. If any dirt or grit should get on to the material,

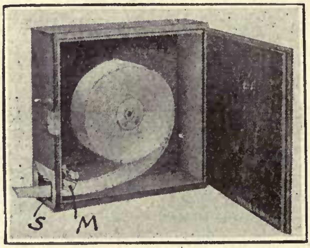

FIG. 161A.

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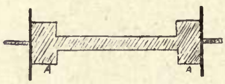

FIG. 161B.

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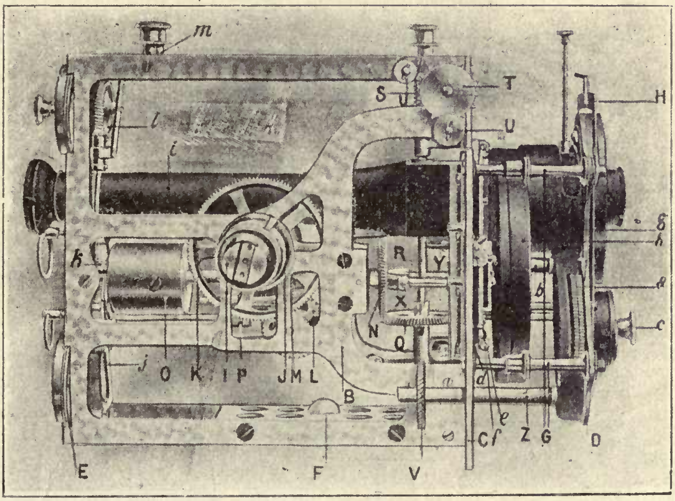


FIG. 164.

is of the type illustrated in Fig. 144), is mounted on a detachable bracket screwed on to the camera case.

With these cameras the film is driven by hand or by a separate motor, and the camera must be mounted on a tripod or other support. The latter method of driving is very suitable for studio work where a current is available, but is impracticable for outdoor and topical work. Many attempts have been made to devise a camera with a self-contained motor, which can be held in the hand while the picture is being taken, just like an ordinary hand camera,

Different motor mechanisms have been tried, but the only successful type of motor is an air motor, as originally suggested by Mr. Proszynski, whose "Aeroscope" camera

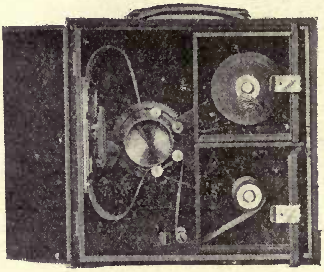


FIG. 165.

(Fig. 166) is the outcome of numerous experiments. The four cylinders A contain air at 300 to 400 pounds pressure, and are in communication with a chamber, B, supplying a

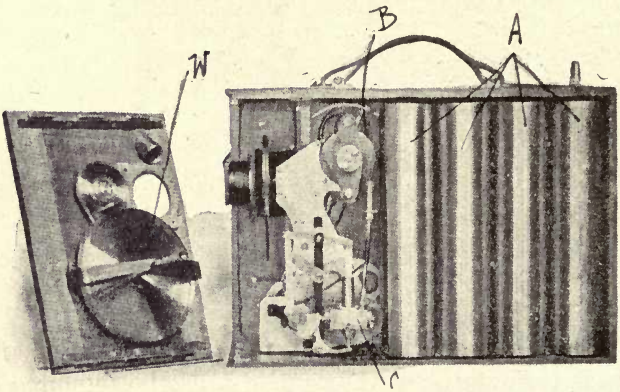


FIG. 166.

constant pressure of air at 40 to 50 pounds to the motor C which drives the claw-feed mechanism. Side by side, behind the cylinders A, are the film spools. The spool boxes have shaped shallow channels, such as A, Fig. 166A,

extending some distance round the periphery of the spool box, forming a light-tight channel slot for the film.

With the motor working in the camera, a certain amount of vibration is to be expected. There are three possible vibrations of the camera, namely: (1) Movements of the camera parallel to the optical axis; (2) oscillations round the optical axis; and (3) angular oscillations of the optical axis.

The first two vibrations are liable to affect the sharpness of the picture, but only to an inappreciable extent, as the actual extent of the vibrations is so very small. The angular vibration or movement of the optic axis would affect the position of the picture on the film much more seriously, and, in order to eliminate any such vibration as

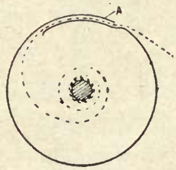


FIG. 166A.

far as possible, a large heavy flywheel, W, is driven from the shutter to rotate very rapidly, which acts gyroscopically to keep the optical axis constant.*

The Camera Stand.—A most important auxiliary for the camera is the stand. In taking Living Picture films absolute rigidity of the camera is a *sine qua non.* The enormous magnification to which a film is subjected on projection (anything between 100 and 200 times) renders it absolutely essential that vibration should be entirely eliminated, and with this object the stand should receive rigorous criticism. In some cases, of course, portability must be considered; and with an apparatus of light build any ordinary tripod of proved reliability may be employed.

* See *Photo Journal*, March, 1913, p. 106.

In addition to rigidity and portability, means must be provided for adjusting the camera, and for following an object to keep it within the field of view. For this purpose tripod stands are fitted with a revolving head (H, Fig. 167), and this revolving head carries a tilting base, B, on which the camera is secured. These two revolving and tilting adjustments enable the photographer to readily point the camera in the required direction, and the adjustments are readily effected by suitable handles.

Such mechanism will usually provide a slow movement of the camera, and auxiliary means are provided on most tripods now in use for rapidly moving the camera round.

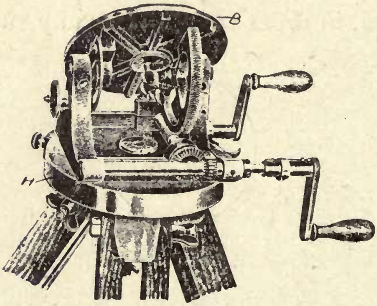


FIG. 167.

For this purpose the handle-turning gear is adapted so that it can be disconnected or thrown out of use, and enabling the camera to be swung round by hand.

The Lens.—For a good Living Picture negative, a good lens is an absolute necessity. In view of the high magnification of the picture on projection, sharpness in the picture is the first consideration, and in the case of rapidly-moving objects, especially, the shorter the exposure the sharper the picture is likely to be. The actual exposure—*i.e.*, the light action on the negative—depends partly on the length of the exposure, and partly on the aperture of the lens through which the light passes. A

wide aperture will allow more light to pass than a narrow aperture. Consequently, if the light is at all poor, it will be necessary to use as wide an aperture as possible. The aperture of a lens is generally given in terms of the focal length; thus, a lens working at F/6 means that, when the picture is focussed on the film, the aperture A, Fig. 168, through which the light enters is one-sixth of the focal length B of the lens; and in the case of distant objects the distance of the lens from the film will be very approximately the focal length. A lens which will work with a wide aperture is, thus, much more rapid than one which will work at a small aperture. There are many lenses available which work at F/3·5. A lens has also recently

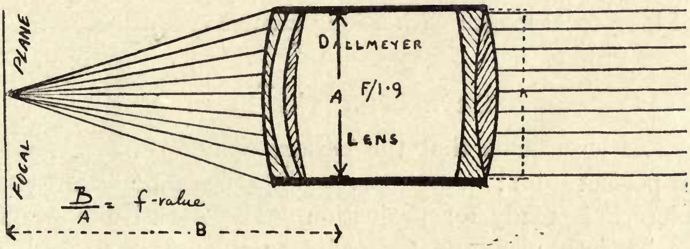


FIG. 168.

been put on the market, by Dallmeyer, with a focal length of 2 inches, and which works at an aperture of F/1·9, and at the present moment is the most rapid lens procurable. Where the light is sufficiently good, it is often advisable to stop down the lens by means of an iris diaphragm, the gradation of tones in the picture, and the distance and perspective effects, being thereby greatly improved.

A telephoto lens is a useful adjunct for filming distant objects. With a cinematograph camera, considerations of rigidity make it impossible to use a long focus lens with a long camera extension. A telephoto lens (Fig. 169) is a combination of a positive element, A, which by itself would give a photographic image like an ordinary camera

lens, with a negative element, B, which by itself will only give a virtual image. The focus of the positive element is at F′, while the focus of the combination is at F. The combination is thus equivalent to a positive lens of long focal length, but works at a much less camera extension, and the function of the negative element is to enable the

FIG. 169.

positive element A to give a more detailed image of a narrower field of view without the necessity of using a lens of long focal length with a long camera extension.

DEVELOPING THE FILM.

Let us assume that the perfect operator has exposed a perfect film; much has yet to be done before the picture is ready for projection. The negative has first to be developed, and the ordinary amateur, who finds a difficulty in keeping his finger-nails from damaging the film of four plates in a single dish, may well stand aghast at the idea of a curvilinear celluloid reptile anything from 100 to 500 feet long, so minute in detail as to render judgment of density difficult, and demanding to be uniformly developed throughout. Of the many methods proposed for development, certain may be taken as types, but as regards the developer only one rule applies. It must be non-staining. Otherwise, in this, as in all other branches of photography, one man's meat is another man's poison, and the golden rule here as elsewhere is to find a developer that suits personal methods, and stick to it. As regards methods and apparatus, there are, broadly speaking, two ways of dealing with the film—(1) winding

it on a framework, and manipulating the framework in the various baths; and (2) feeding the film continuously through the developer and other liquids, and possibly passing it straight through a drying chamber, and reeling it as a finished negative.

Developing Frames, Drums, etc.—Figs. 170A and 170B illustrate the most common forms of frames on which the film is wound for treatment. The wooden frame A is perhaps the most commonly used in conjunction with a vertical tank, which may be grooved to accommodate five or six such frames. The pin frame (Fig. 170B), on which the film is wound in a spiral, can be used with a flat dish. When a drum such as B is used, it is mounted

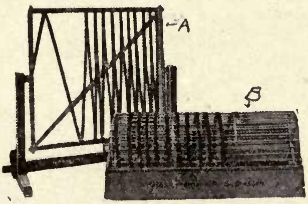


FIG. 170A.

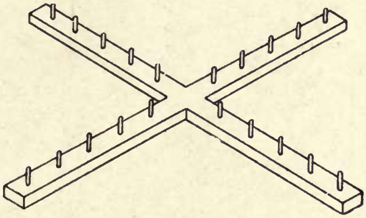


FIG. 170B.

for development over a trough, the lower part of the drum dipping into the liquid. The use of such drums necessitates two persons to lift the drum from one trough to another, whereas frames such as A can be manipulated by one person. Such frames and drums are generally formed of a series of laths, but glass drums may be used. Blair in the early days advocated the use of such glass drums, and that each drum be kept for its own trough and solution, the film being wound from the one to the other at each stage of treatment. A ruby incandescent lamp could be used inside the cylinder to enable the progress of development to be watched. The glass drums were also recommended, on account of the greater security

they offer with respect to cleanliness. The expense of such drums would, however, be somewhat heavy, and it is doubtful if the advantages would be sufficiently great. Two other forms of apparatus are of interest. In Marey's apparatus (Fig. 171), two drums, P, P, are used, the film F, wound in spiral, passing from one to the other. The drums do not themselves enter the liquid, but the film is carried down and under a roller, G, immersed in the trough D. The film might also be passed as an endless band through a long trough, A (Fig. 172), by means of a rotated roller, B.

For drying the film, the most common method is to

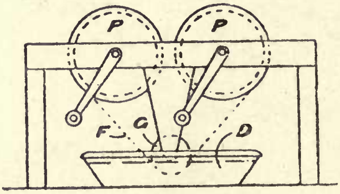


FIG. 171.

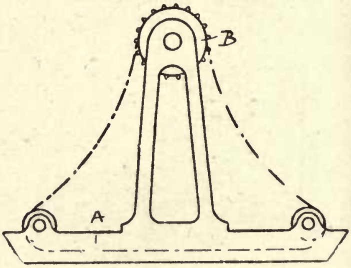


FIG. 172.

wind the film on a large rotated drum, such as B in Fig. 170A, the drum being rotated by a motor in a room which is kept at a uniform temperature of 80° C. An alternative method is to hang the film by hand in a zig-zag path from a series of hooks in the ceiling.

Continuous Processes.—With such frames the necessary winding from one frame to another, though very convenient for comparatively short lengths of film, such as a topical film, is not the most scientific method for large quantities of film. The use of glass drums, as previously described, suggests a method that might be adopted—namely, joining several lengths of film, and running the film on to the drum at one end, and off at the other end,

straight on to the next drum, keeping the drums continuously rotating. The idea of running the film in at one end of a machine, and bringing it out as a finished negative at the other end, is by no means a modern idea, and, in essence, is no more awe-inspiring than the idea of putting raw tobacco in at one end of a cigarette-making machine which is designed to deliver finished cigarettes at the other end. Such a method for developing and

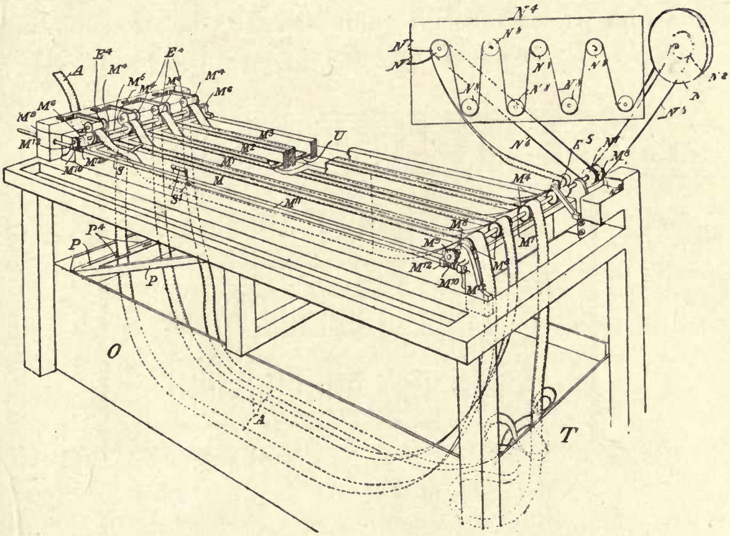


FIG. 173.

finishing the film in a continuous process has, strange to say, yet found very little favour, but is almost bound to be the method of the future. One of the few to realize the scientific value of such methods is Mr. Hepworth, who adopted it from the very beginning. Fig. 173 illustrates diagrammatically the essential features of Mr. Hepworth's apparatus, as described in the British patent specification. Four long narrow troughs, M, M^1, M^2, M^3, side by side, contain respectively developer, fixer, harden-

ing solution, and glycerine solution for preventing the film becoming brittle on drying. At the ends of the troughs are feed sprockets, M^4, on two shafts, M^5, M^7, which are both driven from the worm-shaft, M^{11}. The film A is fed through each trough in succession, passing in the intermediate stages through a water-trough, O, supplied with a continuous flow of water. Weighted rollers, E^4, press the film into engagement with the sprockets M^4. In passing through the water-trough O, the film passes through guide slots, P^4, in an oscillating bar, P. In case of any entanglement, the bar P is

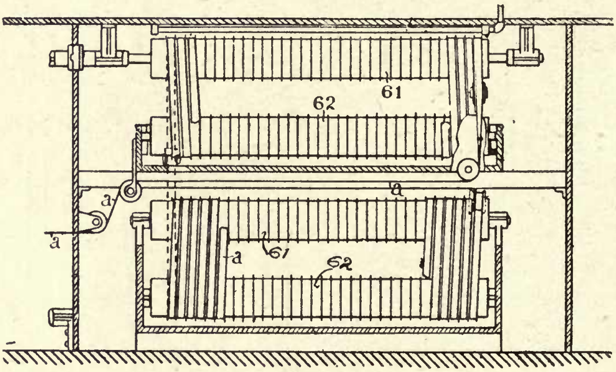


FIG. 174.

tilted, and an alarm sounded. On leaving the trough M^3, the film is fed over rollers, N^8, in a drying chamber, and is finally reeled on a spool, M^2. In Mr. Hepworth's more recent apparatus, the developing and fixing troughs are duplicated one above the other, and the film passes horizontally in a zigzag path through the water-trough, round a series of sprocket rollers at the ends of the water-tank, and the balanced bar P is found to be unnecessary. The films are reeled direct from the washing tank, and the reeled film passed to a separate drying room. In other varieties of suggested apparatus, the film is fed

through vertical tanks over suitably-positioned rollers, and a large variety of apparatus of this type is possible. In a recent apparatus (Fig. 174), devised by Mr. Thornton, the film is fed in a long helical path over two parallel rollers, 61, 62, the lower rollers dipping into the developing and other troughs to an adjustable extent. The rollers are provided with a series of guide flanges, to guide the travel of the film.

Producing the Positive.

The negative, exposed, developed, fixed, and dried, is of course only a means to an end; a positive must now be made from it. In this series of operations, even more care is required than in producing the negative. When bands of any substance are subjected to the action of solutions and incidental strains, there is always a risk of irregular shrinking or stretching, and any error due to this cause is liable to be doubled in intensity by the time the positive is completed. In addition, the pictures should stand at mathematically equal distances apart, and any looseness or irregularity in the printing may cause a variation first in one direction and then in another. The result is a slight want of registration between successive views, giving a most annoying, tremulous motion to the picture when projected on the screen. There are some steps in the production of a picture film in which makeshift apparatus may with more or less impunity be used—the developing arrangements, for instance. So long as the trays hold water, and the room is dark and the solutions right, any makeshift of apparatus will do so long as the film is handled carefully. There must, however, be no makeshift about the camera nor about the printing apparatus.

There have been a large number of machines constructed for use as cameras and projectors which may also be used for printing, more especially those in which

intermittent claw-feed mechanism is used. As, however, the vast majority of cameras are not so adapted, a machine specially adapted for printing postives becomes necessary. Such machines are, broadly speaking, of two classes: (1) Continuously-moving-film machines, in which the negative and positive films move continuously across an illuminated printing zone; and (2) intermittently-moving-film machines, in which each section of the film is in turn passed through a frame, and during the stationary interval is exposed either by means of a shutter, or by switching the light on and off synchronously with the movement of the film.

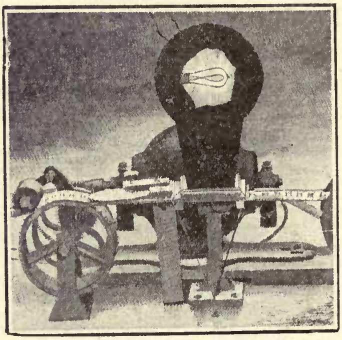


FIG. 175.

Continuously-Moving-Film Machines.—This type of machine was used in the early days by Jenkins and Marey. Fig. 175 shows the machine used by Jenkins, which is still quite representative of modern machines of this kind. It will be seen that a sprocket wheel is used to hold the films in registration, each film passing independently from one spool to another, but held in close contact, negative uppermost, between two plates under a shielded incandescent lamp.

A very important point in contact printing apparatus is the maintenance of a good contact between the films at

all points. A slight arching of the section of film exposed is one means of obtaining good contact, and is perhaps even more effective than flat pressure. Also, when the film is arched in one direction, it cannot buckle in the transverse direction, but, on the other hand, will be extended through an even surface.

In another early machine by Mr. Joly (Fig. 175A), the films are brought together in passing through an inclined guide, F, and are exposed in passing over a sprocketed

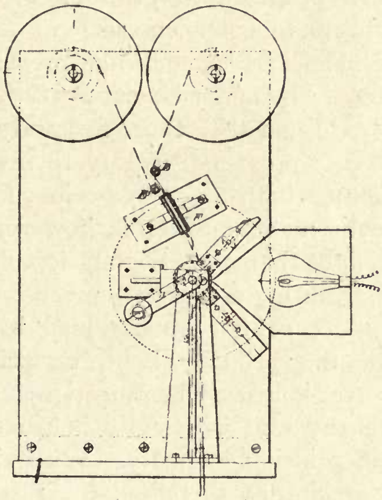


FIG. 175A.

roller. In such apparatus exposure is determined by three factors: (1) The length of the printing zone, (2) the rate of movement of the film, and (3) the intensity of the printing light—any one of which can be varied. In the intermittent-movement type, on the other hand, the exposure is determined by two factors only: (1) The rapidity of the intermittent movement, and (2) the intensity of the printing light. The continuously-moving type has thus an extra variable in the length of the printing zone, whereby the exposure can be increased without slowing

down the speed, and thereby reducing the output. As against this advantage may perhaps be put the possible risk that, in passing over a curved sprocket wheel, there is more tendency to a variable strain on the film, with consequent irregularity; whereas in the intermittent-movement machines, in which a claw feed is generally used, the claw feed serves to maintain a very exact register.

For positives sensitized with silver emulsions, a comparatively short exposure is sufficient. It has, however, recently been proposed to print on to films sensitized with a bichromate emulsion, such as are used for the gum-bichromate, carbon, and like processes in ordinary photography. The materials necessary for such films are considerably cheaper than those necessary for silver printing; also, if they prove satisfactory, their value for making tinted or composite two- or three-colour films may be very great. A bichromate emulsion is, however, very much less sensitive to light than a silver emulsion, and the exposure necessary in printing is therefore much longer. The prolonged exposure cannot be obtained by increasing the intensity of the printing light, because increased intensity involves increased heating power, and the heating limit which the film will stand is reached long before the required printing intensity. With the intermittent-movement apparatus, therefore, the result of prolonged exposure would necessitate such a small rate of printing that the output would be too small to be of any value. Mr. Thornton overcomes the above difficulties by (1) taking advantage of the additional variable in the continuous-moving-film type of machine, and enlarging the printing zone along which the film travels to many yards; and (2) using mercury vapour lamps for printing, in the form of long tubes which can extend all the way along the printing zone. An additional advantage of these lamps is that they have a high printing but low heating power.

In one type of apparatus (Fig. 176) the negative and

positive films are carried over the surface of a large drum, A. The surface of the drum is padded so as to slightly arch the films, F, G, which are pressed into contact with the drum by an endless transparent band, B, or by endless rubber bands pressing on the edges of the films. The printing light in the form of long mercury vapour tubes, C, extends nearly the whole length of the track of the film. If necessary, the apparatus may be kept cool by a supply of cold air through the pipe *d* and casing D. In another form of apparatus the films are carried in a long straight course of many yards between two endless bands

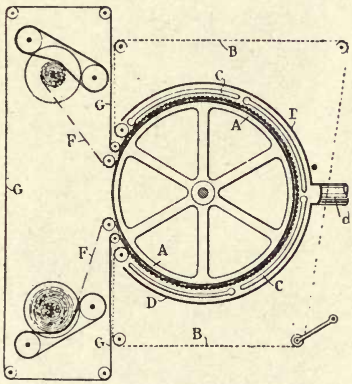


FIG. 176.

travelling in side-guides along the printing course, and these guides are arranged so that the films are slightly arched, to obtain good printing contact. A series of mercury vapour tubes extends along the printing course. In yet another form the films are temporarily secured together by an easily removable adhesive, and travel in a helical course over two parallel rollers similar to the rollers in Fig. 174. The series of mercury vapour tubes is arranged between the folds of the films.

Intermittent-Moving Machines.—In these machines the motion of the film is the same as in the projector, except-

ing that the movement of the film is slower and the stationary period longer. Williamson's printer (Fig. 177) illustrates this type of machine. The printing box is divided into two compartments. The upper compartment contains the printing lamp J, and is lined with asbestos; the lower compartment O contains a motor

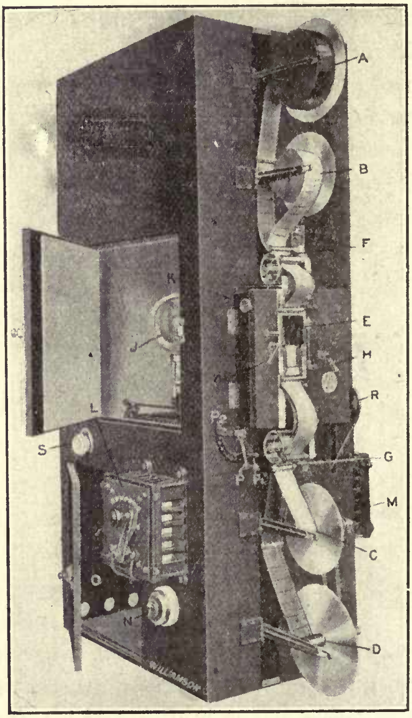


FIG. 177.

and a system of cone pulleys to give four speeds therefrom. Each of these four speeds is further controlled by a regulating switch, L, giving six speeds to the motor. This combination thus gives twenty-four alternative speeds. The printing lamp J is adjusted towards and away from the films by the handle P, and is further con-

trolled by a switch, M, to vary the intensity of the printing light. A very wide range of exposures is thus obtainable. The lamp J is a focus lamp having a grid filament. The feed and other mechanism is mounted on a brass plate, U, Fig. 178, fitting a mahogany frame hinged to the front of the cabinet, and the working parts are thus protected. The negative and positive films A, B, travel over the sprocket F, through the printing gate E, being clawed down intermittently by claw mechanism, T, of the kind shown in Fig. 144. From the printing gate

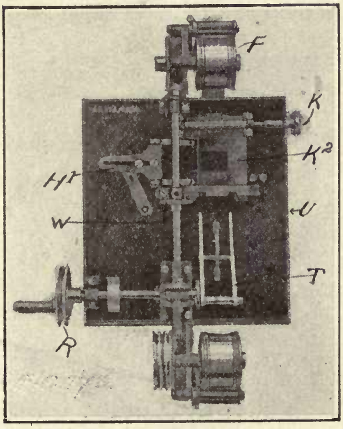


FIG. 178.

the films travel over the sprocket G, and are wound on the spools C, D, or, alternatively, the printed positive may be passed directly into the developing apparatus. The bevel wheel W actuates a shutter which intermittently shuts off the light from the films synchronously with the feed mechanism. In printing films of different density, the speed of the motor, the intensity of the light, and the position of the lamp, may be varied by the resistances L, M, and the handle P.

The Debrie printer (Fig. 179) has similar character-

istics, but varies in design and details. The lamp is focussed on to the films by a lens which is also adjustable. The lower switchboard controls the motor, and the upper switchboard with the voltmeter controls the printing lamp. After leaving the upper sprocket wheel, the negative film enters a brass guide fitted with friction rods, by which it is held back to a certain extent, to allow for the difference in gauge due to shrinkage during development. The lower part of the gate consists of a

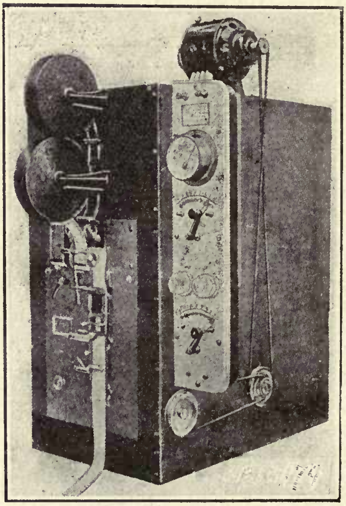


FIG. 179.

long parallel channel in which the films fit perfectly, thus insuring accuracy, and the centering of the films is consequently automatic. The films are held during the printing period by an intermittently-actuated clamp, and adjustable spring plates hold the film lightly when moving forward. The shutter consists of a two-part red and green revolving disc, the red part cutting off the light during the shifts, but allowing inspection; and the green light for printing is intended to increase the contrasts in

the printed film, and gives a better gradation of tone. It is estimated that such machines will print about 1,000 feet of film per hour from an ordinary negative.

For printing special positives, for example, in which the pictures may have to be printed in a special order, the printing machines have to be specially modified for the particular purposes.

Perforating the Positive.—Owing to the fact that in the camera the film is fed by means of perforations, the negative film must be perforated before exposure. In the operations of developing the negative there is a certain shrinkage in the film. Consequently the spacing of the perforations in the finished negative are slightly smaller than in the undeveloped negative. Where intermittent-moving-film printing machines are used, the positive must of necessity be perforated before printing, in order to obtain simultaneous intermittent feed. The perforation gauge for the positive film should, strictly speaking, be very slightly less than the gauge used for the negative film, by just the amount due to shrinkage in the finished negative. When the positive is developed and finished, there will then be an additional slight shrinkage. Where continuous printing machines are used, there is no method of positioning the pictures to the perforations, and it is thus necessary to perforate the film after it is printed and finished. In all such cases, and especially where there is any likelihood of any variation in the spacing between the pictures, as is found to be the case with bichromate printing methods, the provision of means for adjusting the spacing of the perforation is very valuable, and in a still further degree the provision of means for visually inspecting the film as perforation proceeds, so as to be able to adjust the spacing.

Developing the Positive.

The development of the positive film is conducted in the same manner as for the negative film, but the different

character required in the resulting film requires consideration. Density and gradation must be carefully watched. Light is of extreme value in living-picture projection, and

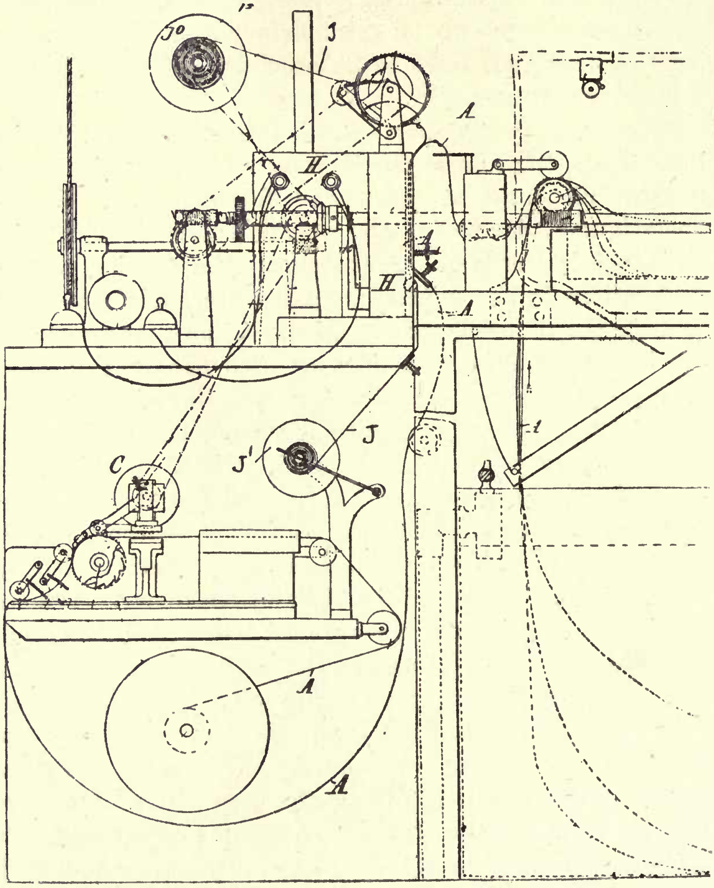


FIG. 180.

the image must therefore not be too dense. At the same time all detail must be secured, and some deposit be present over the whole extent of the picture; and sparkling points have a distressing habit of drawing attention to the failings

of flicker and incorrect registration, even when only present in the slightest degree. In developing the positive, the value of apparatus in which the film is passed into the developer as soon as possible after leaving the printing apparatus is especially high. The complete plant devised by Mr. Hepworth is illustrated diagrammatically in Fig. 180, and includes a perforating machine, C, the printing machine H, and the developing plant shown in Fig. 173. The negative film J is passed from the spool J′ to the spool J°, and joins the already perforated positive film A just before entering the printer H. The printed positive then immediately enters the developing trough, and by the visible image developed it can be seen whether the

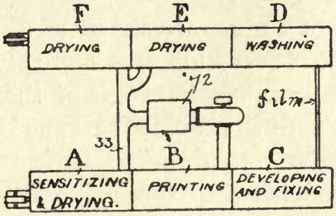


FIG. 181.

printing is correct and the printing light adjusted. It is possible with such apparatus to join a whole series of negative films and print a complete spool straight off, instead of joining a series of positive films. Means are adapted whereby an audible alarm is automatically given whenever there is a change of density in the negative, thereby indicating the necessity of readjusting the printing light.

In another complete outfit devised by Mr. Thornton, the different sections, A, B, C, D, E, F (Fig. 181), of the plant, are not tanks or boxes, but rooms of formidable dimensions. The hot air from the lamps in the printing room B may be utilized for drying, and forced by a pump, 72, into the drying rooms A, E, F.

Retouching and Colouring.

Development and drying ended, the film is ready for projection, subject to such improvement and rectification as retouching can supply. Flaws and spots are fatal. In a single picture they are detrimental enough, but their presence in a film of successive views gives rise to a twinkling and flickering effect, due to their sudden perception and equally sudden disappearance, which is irritating and fatiguing to the eye.

The film may be tinted with uniform colour, thereby giving a very pleasing, and in some cases appropriate, effect. Or it may be coloured, and on this subject a few remarks may not be out of place. In an ordinary lantern slide outline is of comparatively little moment, but in a Living Picture it is everything. A spire of a church in the single view does not offend the eye if the colouring oversteps the proper outline, provided that the shape is rendered symmetrical. Far other in a Living Picture. The slightest variation between successive views gives rise to a continuous bulging and contraction which no respectable church would allow its steeple to indulge in. Illusion of motion is due to alteration in position of their outlines as compared with that of stationary objects, and this progression is minute in successive views. The slightest inaccuracy in colouring may neutralize this, and render the steps by which an object is apparently advanced far more jerky than is the case in the photographic views. Therefore the colouring should be in the nature of tinting rather than partaking of the gaudy display of the average lantern slide. In the early days colouring was done by hand, each picture being separately coloured. To colour a small picture measuring 1 inch by $\frac{7}{8}$ inch is very different from colouring an ordinary lantern slide $3\frac{1}{2}$ by $3\frac{1}{2}$ inches, and a magnifying glass was necessary. As films began to increase in length, and when several copies were wanted,

the labour and cost involved were very great, and it became apparent that other methods were required. The stencil process has been adapted and perfected, particularly by the firms of Gaumont and Pathé, and forms an art in itself. Three stencil films are necessary for each picture. Each stencil is in the nature of a mask which is registered with the film, but leaving openings where the colouring is to reach the film. Three stencils are required—one for applying the yellow, a second for the red, and a third for the blue. The stencils have in the first instance to be made by hand, but serve for a large number of copies, and the colours are applied by special machines.

Protecting Films.

As regards the protection of films little has been done. Machines are constructed with the greatest care, and every possible precaution is taken against damage to films in the course of projection; but where will the lantern-slide maker be found who will send his wares out without cover-glasses? It has been proposed to cement a plain film by its edges over the positive. This, however, would double the thickness of the film, and it is well understood that celluloid obstructs light to a greater extent than glass. It has also been suggested to confine the attempt to the strengthening of the margins, leaving the security of the picture surface to be attained by perfecting the structure of the film gate. Films are, however, sometimes coated with a celluloid varnish, which protects the film surface from scratches.

Joining and Repairing Films.

Before the film spool is passed into the exhibitor's hands, it is very probable that a number of sections of the film have to be joined together, and rejoining the broken ends of a film is also an operation which, unfortunately, has to

be frequently performed. If the film is torn right across a picture has to be sacrificed. The perforations may become damaged, and must be replaced, or a sideways strain will be placed on the film, which will inevitably end in rupture of the band sooner or later. The two solvents for celluloid are amyl acetate and acetone, the latter being preferable. The ends of the broken film must be trimmed so as to render the two proximate pictures at an exactly correct separation, and the junction must be freed from grease and film, and scraped down so as not to leave an

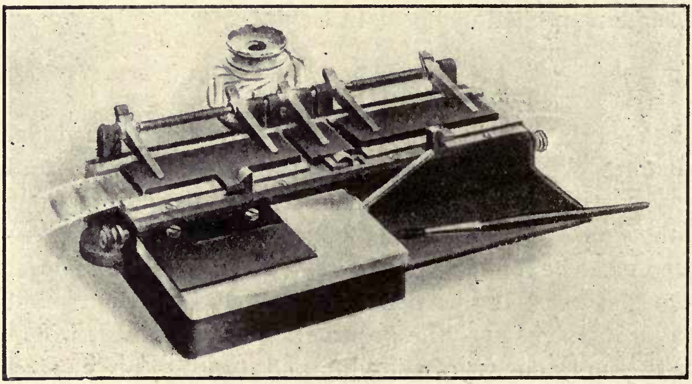


FIG. 182.

abrupt thickening where the edges overlap. The film-mender (Fig. 182) usually has two clamping plates carrying pegs which register the ends of the film in position, and between these clamping plates is a presser plate for pressing the joined ends. For non-flam films a special solvent is usually provided.

CLEANING AND RENOVATING FILMS.

To obtain a clear picture on the screen, it is necessary that the film be free from stains, grease, and other

markings, which are bound to appear on the film some time during its career, however carefully the film is used; and unless the film is a new one it is often very advisable to put it through a cleaning process before use. It may be that smears or marks are left on the film after its treatment in the developing, washing, and fixing solutions, though this should not be so if the film is properly treated and handled. Debrie's cleaning machine (Fig. 183A) is more especially devised for removing such stains. The

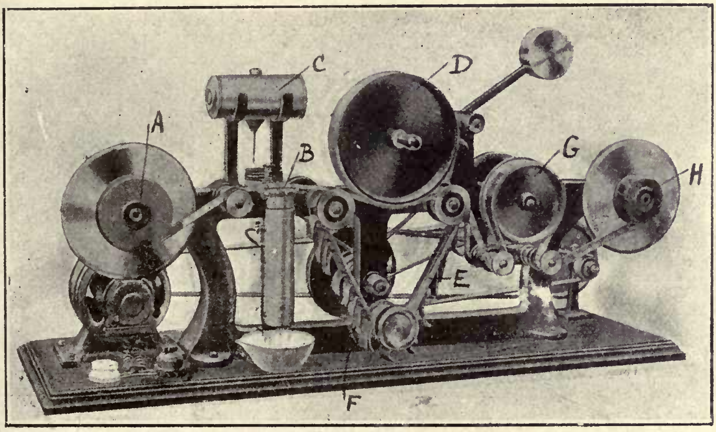


FIG. 183A.

film passes from the spool A over a wick-pad, B, which receives a regulated supply of alcohol from the tank C. The film is cleaned by being drawn between a rubber-covered roller, D, and an endless band, E, which is provided with a series of chamois leather pads, F. The roller and band are driven in an opposite direction to the travel of the film, which then passes over the rubber-coated roller G by which the film is drawn through the machine.

For removing scratches it has been suggested to apply

a thin coating of celluloid, so as to fill in the scratches and leave a smooth, even surface.

To remove grease and dirt from a film, benzoline is one of the most satisfactory fluids to employ. Methylated spirit has the tendency, not only to make the film curl, but also to take the nature out of the film and leave the surface dry and brittle. Benzoline, on the other hand, is a mineral oil, free from acid, and feeds the film in much the same manner as grease and oil feed leather. Fig 183B illustrates the Seabourne film-cleaning machine. The

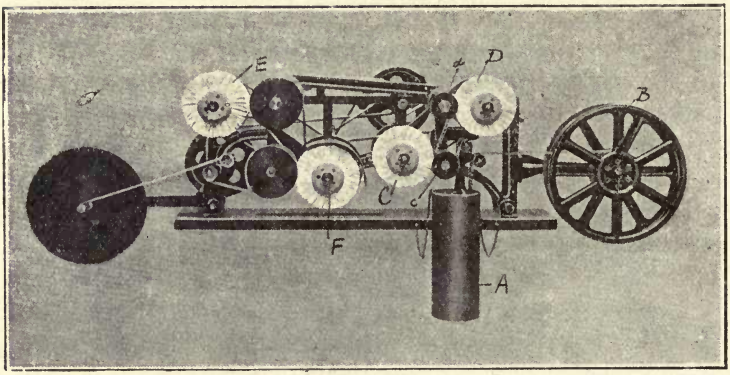


FIG. 183B.

benzoline is contained in the tank A, and the film passes from the spool B under a roller in this tank, and then round wiping rollers, which wipe off superfluous moisture and fluid before the film passes against the cleaning brushes C, D. These brushes are formed of a ring of strips of chamois leather, and rotate at a speed of 2,000 revolutions a minute. The film is lightly pressed against them by rollers, *c*, *d*, and then passes against another similar pair of chamois leather polishing brushes, E, F, before being rewound. The pieces composing the brushes are always tending to fly apart, and any dirt or grit is thrown off by

centrifugal action. The brushes E, F, dry the film, and leave an extremely fine coating, which not only preserves the suppleness of the film, but acts as a preservative.

Here, then, the film passes into the exhibitor's hands, and any further remarks regarding it must be relegated to the next chapter, wherein are described many accessories and aids which render the exhibitor's life endurable, if not happy.

CHAPTER VI

EXHIBITING, ETC.

The projector—The optical system—Illuminants—Screens—Stands—Film-gate and steadying devices—Film centering—Shutters and flicker—Fire-preventing and safety devices—Film manipulation and housing—Stereoscopic projection—Kinoplasticon—Cinelife—Peep-shows—Living pictures at home.

IF the modern projector is a very much more complicated machine than the earlier machines, the pictures it is possible to project are correspondingly superior. With the great variety of choice of excellent machines, there is hardly any excuse at the present day for a bad picture show, although, of course, the most perfect projector is of comparatively little value in the hands of an ignorant or careless operator. In dealing with the various problems arising in the exhibition of Living Pictures, we shall have occasion to describe in more or less detail many variations in constructions of actual machines, and it will facilitate both the task of describing and of following them, to first describe the general construction of a typical machine. The fact that the Gaumont Company have a continuous record of construction from the earliest days suggests the appropriateness of taking their Chrono projector as a typical machine for this purpose. The machine, Figs. 184A, 184B, is a Maltese cross machine.

The whole apparatus is supported on a strong frame or stand, such as illustrated in Fig. 194. The lantern O, nearly always asbestos-lined, is mounted on transverse rails, R, which enable the lantern to be moved across the

stand to utilize either the lens L for the film, or a second lens, L′, for ordinary magic-lantern slides. The transverse rails R are themselves adjustable along rails, R′, to adjust the lantern towards and away from the lenses L, L′. The condenser mounting C is outside the lantern body, so that

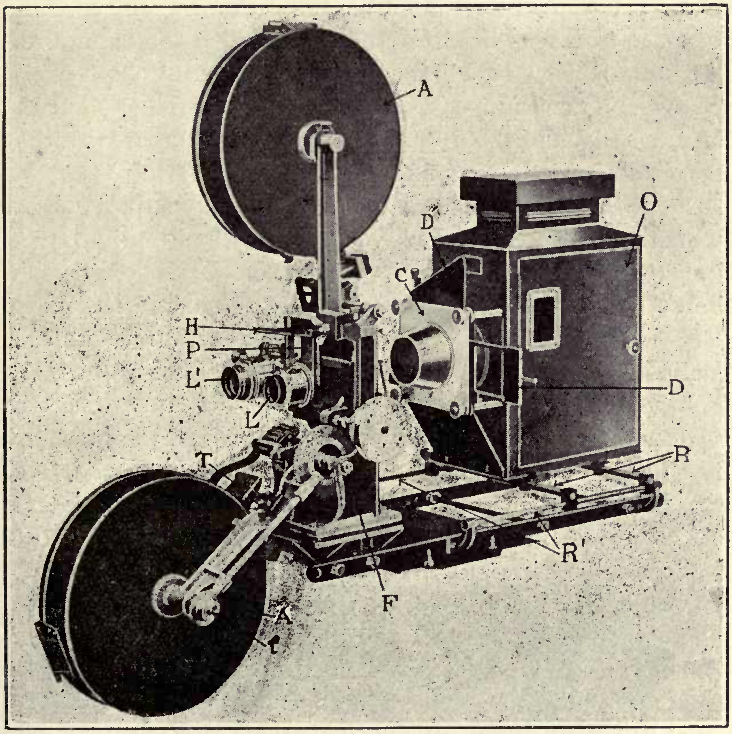


FIG. 184A.

the condenser is accessible from the outside of the lantern. The slide-carrier D carries in one half an opening for the slide, and on the other half an opaque cut-off, which cuts off the light from the lantern when the carrier is drawn to the position shown. An auxiliary cut-off, D′, is formed of two adjustable slides with semicircular ends. The

front part of the apparatus carries the film mechanism, film spools, and all the projector machinery. The film is contained, to start with, in the upper spool box A, which holds about 1,500 feet of film, and after passing through the projector is spooled in the lower spool box A′. Both spool boxes are fireproof, and are fitted with fire-trapped slots, T, designed for the purpose of preventing fire spreading into the spool boxes if the film happens to catch fire. The film is drawn from the upper spool box by a sprocket, K, which is continuously rotated from the driving shaft F, and the edges of the film are kept in engagement with the sprocket teeth by a resiliently mounted spring roller *k*. A loop, *l*, is left between the sprocket K and the gate G, which is being continuously fed and intermittently drawn in as the film passes through the gate. This loop prevents any tension on the film while it is stationary in the gate. The feed sprocket is seen at S, and the film is pressed against the sprocket by extensions, X, X, of the runners W on the hinged back of the gate. These runners exert a yielding pressure on the edges of the film, and the pressure is adjustable. A second loop, *l′*, is left between the feed sprocket S and the continuously-rotating take-up sprocket K′, which is on the main driving shaft F, turned by the handle *h*. The edges of the film are pressed against the sprocket K′ by resiliently-mounted rollers similar to the upper roller *k*. All the sprockets and rollers over which the film passes are shaped so that the film is in contact therewith only at the edges, and not on the face of the film. The film thus travels through the machine in a hollow track. The shaft *t*, on which the take-up spool is mounted, is positively driven by bevel and shaft gearing from the main driving shaft F, and the spool is driven by a spring friction clutch, so that the speed of the spool may accommodate itself as the diameter of the film wound increases, and at the same time prevent the film being wound loosely on the shaft. The slip gear can be adjusted

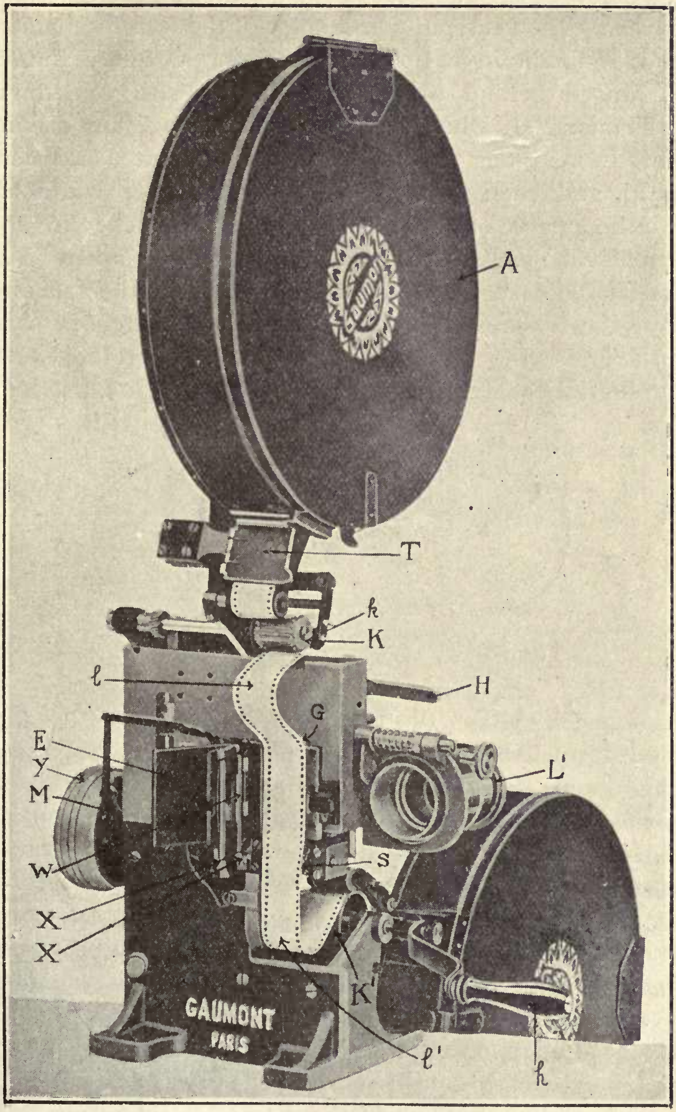


FIG. 184B.

by a screw as the diameter of the wound film increases. A flywheel, Y, on the pin-wheel shaft of the feed mechanism tends to maintain a steady feed motion. A safety shutter, E, hinged behind the gate, is linked with centrifugal mechanism, M, which is geared with the main driving shaft F. So long as the handle *h* rotates at a sufficient speed, and each picture is moved on after being fed into the gate before it becomes heated and catches fire, the centrifugal mechanism maintains the shutter open. The shutter closes behind the gate immediately the machine slows down below the safety limit. Immediately in front of the film is the shutter, Fig. 184C, which is rotated from the shaft F sufficiently fast not only to cut off the light

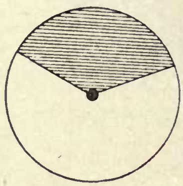


FIG. 184C.

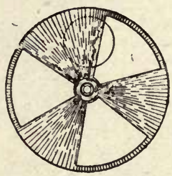


FIG. 184D.

during each shift of the film, but also to cut off the light once during the interval of projection of each picture. This double cut-off is to minimize flicker. In the latest model of the Chrono projector, a three-sectored shutter, Fig. 184D, now the most common form of shutter, is mounted on a rotated arm projecting in front of the apparatus, and so that it intercepts the light just about where the light comes to a focus in front of the projecting lens L. The shutter is driven to make one complete revolution for each picture succession interval, so that it not only cuts off the light during the actual shift of the film, but twice in addition while the picture is projected on the screen. In front of the gate is a sliding panel, P, which carries a gate mask and the lens L. The gate

mask is for the purpose of outlining the boundary of each picture projected, and the panel can at any time be adjusted vertically by the lever handle H so that the mask may include just one picture, and the accompanying motion of the lens keeps the projected picture centred on the screen.

The gearing of the machine is arranged so that eight pictures are fed for each turn of the handle *h*, which is normally turned at a rate of two revolutions per second. The projector is, of course, often run by motor, in which case a motor-driven pulley is secured to the driving shaft F.

Instead of taking a series of projectors of various types and describing the individualities of each separately, it will be better to take in turn the different sections of the projector and projecting system, and to note variations and modifications of these, some of which are in use and to be found on modern machines.

The Optical System.

The essentials of the optical system are illustrated in Fig. 185. The function of the condenser A is to collect as much light as possible from the source O and condense it on to the gate G, where the picture projected is situated. The circle of light x, x, should completely cover the gate mask, and leave a margin of light for adjusting the mask. This margin must be sufficient to allow for adjusting the mask and gate when this method of centering the picture on the screen is used, as in the Chrono machine.

The function of the projecting lens B is to project a magnified image of the illuminated picture on the screen. In view of the magnification of the picture as much light as possible is required, and it will be seen that the amount of light collected by the condenser depends upon the angle

of the cone of light LOM. The larger the condenser, therefore, and the nearer the light to it, the larger the amount of light collected. The larger the condenser is, however, the more expensive it is; the light O must also be situated beyond the focus F of the condenser, the position being determined by the distance of the projecting lens B from the light; also, again, the nearer the light is to the condenser, the hotter the latter will become.

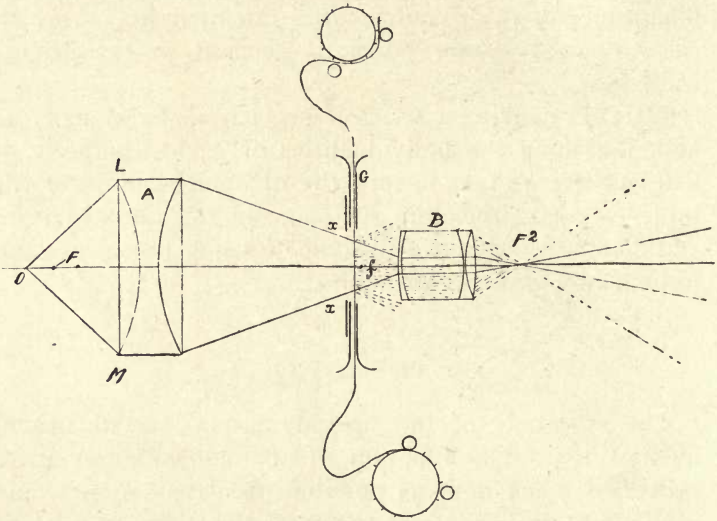


FIG. 185.

The actual size and focal length of the condenser used must be a compromise between these conflicting requirements. Condensers varying from 4 inches to 14 inches diameter, and between $2\frac{1}{2}$ inches to 12 inches focal length, can be obtained; but in practice condensers of 4 or $4\frac{1}{2}$ inches diameter, and 3 to $3\frac{1}{2}$ inches focal length, are the most common in use.

Owing to expansion due to heating, a suitable mounting of the condenser is important. The glass must have

ample room to expand in the mount, and the mount itself should fit loosely. A massive mount supplying a large conducting surface, and with openings for ventilation, is advantageous. An alternative method is to mount the glasses of the condenser between spring claws, such as C, Fig. 186. These claws C can slide in the frame A as the glass expands. Separate frames, A, B, are used for the back and front components of the condenser, and will only fit in their respective slides, so that the component glasses cannot be incorrectly positioned.

It is in all cases advantageous to have the condenser

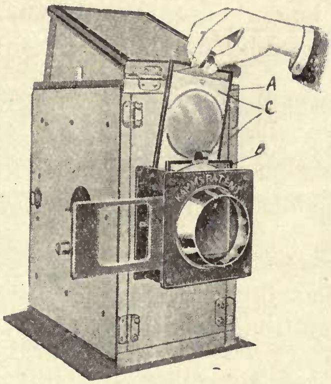


FIG. 186.

mounted on the outside of the lantern body, so as to enable easy access thereto in cases of breakage. Any condenser is liable to break owing to unequal expansion or contraction in the glass, a good condenser being less liable to break than a cheap one. Other common causes are, too sudden heating and too sudden cooling of the condenser. To avoid the former the condenser should be warmed gradually, and not exposed suddenly to the full force of the arc lamp or projecting light. This may be done by starting with a weak light, or by keeping the light away from the condenser until it is warm, before

moving it up into position. The second cause is avoided by abstaining from any attempt to artificially cool the condenser by means of draughts, contact with cold surfaces, or other equally disastrous methods.

The choice of a projecting lens is an important one, as it is the lens which affects the magnification of the picture, and for a good sharp picture a good lens is necessary. The focal length of the lens required is determined by the size of the picture and the distance of the projector from the screen. The usual formula for a magnified image of a circular disc is—

$$\frac{\text{diameter of image}}{\text{distance of image from lens}} = \frac{\text{diameter of disc}}{\text{distance of disc from lens}}$$

In cinematograph projection the gate is, as a general rule, so near the focus f, Fig. 185, of the lens that the distance of the picture from the lens is practically the focal length of the lens, and for rough approximation the formula becomes—

$$\frac{\text{size of projected image}}{\text{distance of screen from projector}} = \frac{\text{size of gate}}{\text{focal length of lens}}$$

Having any three of these quantities given, therefore, the fourth required quantity is readily determined to a sufficient approximation.

The light, condenser, gate, and lens, must be correctly positioned. A convenient way of doing this is to put a temporary picture of a non-inflammable nature in the gate, such as a thin piece of transparent paper or glass bearing an image, and to centre and focus the image on the screen, arranging the lantern so that the centre of the gate and the lens are in the line joining the centre of the condenser and the centre of the screen. This temporary slide can then be removed, and the light adjusted until as much as possible of the centre of the screen is filled with

a clear white disc, such as *h*, Fig. 187. If the light is not properly centred, effects on the screen such as *a*, *b*, *c*, *d*, *e*, *f*, or *g*, will be produced according to the wrong position of the light. When the light, condenser, and lens, are correctly adjusted, the condenser will be brought to a focus at a point, F^2, slightly in front of the lens, and not within the lens, as is so often explained. The shutter is often placed at or near this position F^2, and it is, strictly speaking, the most correct position for the shutter.

The aperture of the lens has an importance which is often overlooked. Of the light which reaches the picture, part is directly passed through the picture and the lens, in proportion to the transparency of the picture. If this

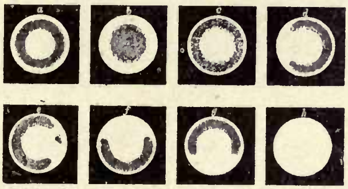


FIG. 187.

transmitted light were the only part to consider, there would be no point in having a lens with a larger aperture than the diameter of the entering cone of rays. Not all the light gets through the picture, however. A large part of it is diffused by the particles forming the image—that is, wherever the film is not transparent. The opaque parts of the picture in the gate constitute, in fact, a highly luminous object, and the rays emanate from these parts in all directions, as indicated by the broken lines in Fig. 185. It is desirable, therefore, to collect as much as is possible of this diffused light, and, clearly, a large aperture will collect a larger cone of rays than a small one. A lens which has a large aperture—*i.e.*, a high F value—is thus a great advantage.

The handling of the lens is another important point for the operator. The lens should always be handled with great care, and the glass touched or rubbed as little as possible; a piece of cotton-wool or a piece of clean linen should be used, never a rough duster or cloth which may be in the slightest degree greasy, rough, or gritty. A very convenient device for handling a lens is the handle *h*, Fig. 188, provided on the Cineopse lenses provided by Guilbert. The component elements of these lenses are

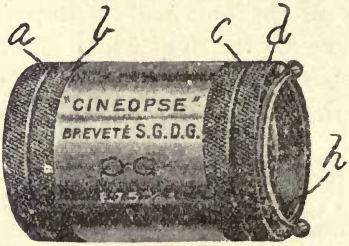


FIG. 188.

mounted in rings, *a*, *b*, *c*, *d*, which cannot be put together in any but the correct order, and the lenses can thus be cleaned without touching the glass itself.

A recent method of illumining the picture in the gate has been introduced by Newton and Co., consisting in substituting for the condenser a large concave mirror behind the light, and for the projecting light a mixed jet of oxygen and compressed acetylene plays on a small pastil at or near the focus of the mirror, and so as to produce a converging cone of reflected light to illuminate the gate. A much larger mirror can be used, and a greater amount of the light from the pastil collected, than with the ordinary condenser.

THE ILLUMINANT.

The question of lighting is, perhaps, somewhat out of place here, being common to all branches of projection work; and it is manifest that the system of lighting employed need not, and indeed does not, affect the mechanism employed for the presentation of Living Pictures, although it has a considerable influence on the result on the screen. Still, the choice and handling of the various illuminants is a sufficiently important one to justify a few remarks on the subject. For safety and power the arc lamp is undoubtedly pre-eminent, and, with

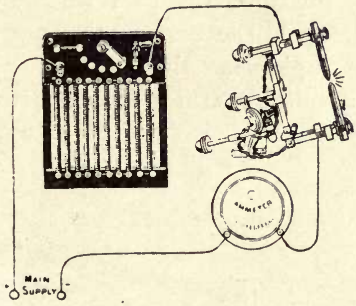


FIG. 189.

the rapid extension of public electric lighting, an electric supply is available in most large halls. A direct current supply on a low voltage is the most convenient and the most efficient. The upper carbon is connected, as shown in Fig. 189, to the positive pole of the supply through a cut-out resistance; and the action of the current is to form a hollow or crater, Fig. 190, *a*, where the light is concentrated, while the opposite pole very conveniently burns to a fine point. A convenient test for the right connection is to throw an image of the arc on the screen by removing the projecting lens. The crater or hollow should be projected in an inverted position on the screen,

and the upper carbon should appear on the screen as the lower one. The light is more steady with a direct current than with an alternating current, which sometimes has a tendency to revolve round the carbons and to cause an

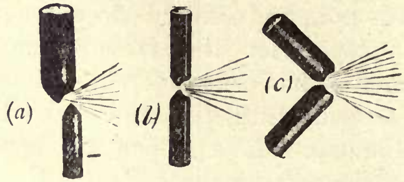


FIG. 190.

unsteady light on the screen. With a direct current a hand-fed arc lamp is the best, as the upper carbon burns away twice as rapidly as the lower one. To assist the formation of a suitable crater directed towards the condenser, the lower carbon is preferably adjusted slightly in

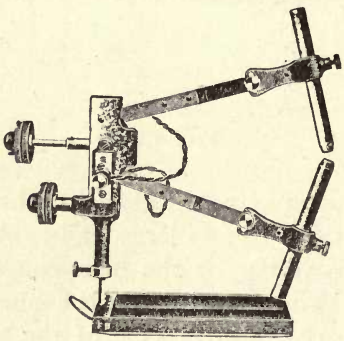


FIG. 191.

front of the upper one, and the positive carbon is cored and of larger diameter than the negative carbon, which is solid. With an alternating current, a type of arc lamp, known as a "Scissors Arc Lamp" (Fig. 191), is often recommended, in which the carbons are set at an angle, and are

centred simultaneously, either from a handle or automatically. A crater is then formed in both carbons, as shown in Fig. 190, *c*. This position of the carbons is preferable to the alternative straight position shown in Fig. 190, *b*.

The voltage of public supplies is generally far in excess of that required to obtain the current for feeding the arc lamp. Generally 45 to 50 volts would be sufficient, whereas the supply is often 200 volts or more. If a high voltage is used the current required can be obtained by means of resistances. The resistance required is determined by Ohm's Law, namely:

$$\text{Resistance} = \frac{\text{voltage}}{\text{current required}}.$$

In calculating the resistance, the total resistance of the circuit, including that of the arc lamp itself, must be taken. With this method, however, a large amount of power is wasted; thus, if C is the actual current used in ampères, and R the resistance of the lamp in ohms, and R′ the auxiliary resistance used to keep the current down to requirements, the power consumed by the resistance is R^1C^2 watts per hour, and this power is absolutely wasted in heat. Unless, therefore, this power can be utilized in some other way, the method of employing resistances is not an economic one. An alternative method is to employ a motor generator—that is to say, to utilize the direct supply at high voltage to drive a motor, and from this motor to drive a generator which will supply a lower voltage for the lamps. In such cases it is useful to have either a duplicate motor generator to fall back upon, or an alternative direct circuit with a resistance. In the case of an alternating current supply the voltage can more conveniently be reduced by a transformer.

If electric light cannot be employed, a good mixed oxy-hydrogen jet limelight is perhaps the best substitute, and

can be used with comparative safety. Other alternatives are: (1) a mixed oxy-acetylene light; (2) a carburetter or ether-saturator along with compressed oxygen. Fig. 192 illustrates a combined carburetter jet, the oxygen being supplied either from a cylinder or generator through the tube 10.

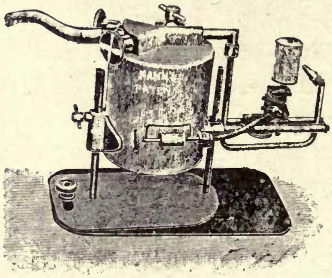


FIG. 192.

The comparative luminosities of the various illuminants are approximately as follows:

	Candle-Power.	
Four-wick oil lamp	80 to	100
Acetylene generators with ordinary burners	100 ,,	250
Oxygen with ordinary house gas used with blow-through jet	300 ,,	500
Oxygen gas compressed in cylinders, and used for mixing jet	1,000 ,,	1,500
Oxygen in cylinder with an ether-saturator or carburetter jet	1,000 ,,	2,000
Oxy-acetylene light with gases in cylinders	1,000 ,,	2,500
The electric arc light	1,000 ,,	100,000

Where a limelight is used a good lime is necessary. Special limes are made for limelight jets composed of compressed oxides of rare earth, thorium, and cerium, baked in electric ovens at very high temperatures. Instead of the usual method of supporting the lime, shown in Fig. 192, the lime is preferably held horizontally, as shown in Fig. 193, by a holder which slips on to the peg provided

for the usual hole in the lime, which with this arrangement can be made solid.

For limelight jets it is, perhaps, on the whole, better to utilize cylinders of compressed hydrogen or acetylene. Not that the other methods are dangerous if properly used, and they may be invaluable in out-of-the-way places where cylinders cannot be easily replenished. Where, however, a carburetter or ether-saturator is used, it is very important that the operator should be fully alive to the

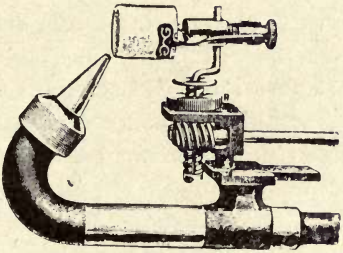


FIG. 193.

possible dangers of these sources of light. On no account should the reservoirs be filled with gasolene or ether anywhere near the neighbourhood of a light, as the vapours of these substances will catch fire at a distance of several feet. They should, accordingly, be filled in the open air, and on no account in a closed operating box. It has often been suggested that some certification of public operators should be required, and there is very great force in this suggestion.

THE SCREEN.

The screen is another important part of a Living Picture outfit. It is no use to secure a powerful illuminant, and then to waste any more than is necessary on the screen. Of the light which falls on the screen, part is transmitted, part absorbed, part reflected. If the pictures are projected from the same side of the screen as the audience, the screen should be opaque, and possess a

smooth, white, diffusing surface. It is a common practice to whitewash the screen, or dip it in a solution of whitewash. Screens made by treating a fine mesh fabric with aluminium are becoming more and more popular. A rough aluminium surface, such as will result by using a coarse or cheap fabric, will not be as good as an ordinary fine calico or linen screen. The only disadvantage of these metallic screens is the tendency to oxidize; but the pictures are certainly improved, and the life of a screen is sufficiently long to compensate for any tendency to oxidization.

Where the pictures are projected from behind the screen a translucent screen is, of course, necessary, and for exhibitions of short duration a wet screen is as good as any. For daylight projection a translucent screen is also necessary, and the screen should be shaded as much as possible from any strong direct light, as, for example, by a conical shade extending a short distance to the front and rear of the screen, the rear opening being slightly larger than the cone of light from the projector.

It is in all cases very necessary to have a perfectly flat surface, and, where a flexible screen is used, it should be uniformly taut across the surface. The screen should also be perpendicular to the direction of projection, and, where the projector is tilted to the horizontal, the screen should also be tilted at the same angle to the vertical, otherwise the picture will be distorted, and will not be in focus over the entire surface of the screen. A very effective addition to the picture is a black border or framing just circling the boundary of the picture.

The Stand.

The stand for the projecting machine should be strong and rigid. It must be remembered that the enlargement on the screen is much greater in a Living Picture than for an ordinary lantern slide, while the apparatus itself is subjected to treatment which no mere optical lantern is

called upon to undergo. The needful rigidity is usually obtained by the use of a strong iron stand, Fig. 194, having arrangements for tilting the apparatus to the required angle. On no account should any hollow body be used as a support. There is a very large degree of sympathy between one sense and another, and there is

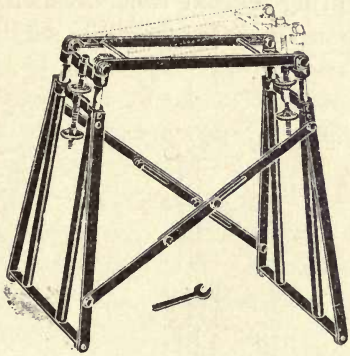


FIG. 194.

little doubt that a continual rattle impinging on the ear tends to intensify irritation caused to the eye by any flicker on the screen, and it is very necessary to minimize or conceal this same flicker as much as possible.

THE FILM GATE AND FILM STEADYING DEVICES.

In the early projectors the film gate was lined with felt or other soft material, with the idea of avoiding wear on the film. It was soon found, however, that grit and dirt had a very nasty habit of collecting in the soft material, and with disastrous results to the film. Also, if the film fired in the gate, the soft fabric was burnt, and the gate had to be refitted before it could be used again. The regulations under the Cinematograph Act prescribe that the film gate shall be of massive construction and shall be provided with ample heat-radiating surface, and that the passage for the films shall be suffi-

ciently narrow to prevent flame travelling upwards and downwards from the light opening.

In nearly all modern machines the film is pressed along the edges only by one or more yielding strips of hardened polished steel, as shown in Fig. 184B, and the pressure of which can be finely adjusted. It has also been proposed to use spring-pressed rollers, which extend at the top and bottom of the gate across the whole width of the

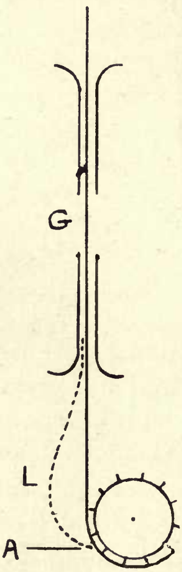


FIG. 195.

film. For intermittently steadying the film in the gate while projected it has been suggested to use a clamping frame, or a steadying pin frame, intermittently operated synchronously with the feed mechanism. In moving through the gate the film gets up a very considerable velocity and momentum, and the manner in which the film is arrested and steadied in the gate makes all the difference to the steadiness in the picture on the screen.

It will be seen from Fig. 195, that when the intermittent feed acts at a point A at a distance from the gate G, and the tractable force suddenly ceases, the momentum of the film tends to carry it forward and to form a loop, L, against the action of the springs pressing on the edges of the film. With a claw feed the claws could be adapted, as in Mr. Proszynski's mechanism, Fig. 143C, to act at the gate in such a manner that they do not leave the film at the end of the downward stroke until the film is stationary, and thereby act to steady the picture for projection. The dog feed cannot be adapted to perform an equivalent steadying function, and the Maltese cross feed only to a very limited extent. The latter cannot be adapted to feed the portion of film in the gate, and the next best thing is to situate the feed sprocket as near the lower edge of the gate as possible, so as to leave a minimum of film between the gate and the feed sprocket. The two runner extensions X, X, in Fig. 184B, serve to guide the film on to the feed sprocket. In Wrench's machine the corresponding runners are slotted for the passage of the sprocket teeth.

In some machines the gate opens at the back, as in Fig. 184B, while in others it opens at the front. In the latter case the emulsion side of the film has a rigid bedding, and the film is inserted and removed on the side remote from the lantern and the light; but there is not much room for opening the gate when short-focus lenses are used, which necessarily work close to the gate. In a recent arrangement on the Kamm projectors this difficulty is avoided. The door of the gate and the lens slide toward and away from the film gate.

Film Centering.

If the successive pictures do not register exactly in the gate, the result will be that the picture on the screen will not keep its position in the centre of the screen, but will

creep up or down the screen. Although such creep is rendered less likely by the precision of modern machines, there are contributory causes, such as any inaccuracy in making a join, or in perforating, or in the spacing of the pictures, which may arise in taking the negative or in printing the positive. All modern machines are therefore fitted with centering means to keep the picture in the centre of the screen, and which can be adjusted while the machine is running. Where, moreover, the projector is run by motor, the operator is much freer to utilize these means to the fullest advantage than where he has to turn an operating handle.

The following are the principal types of methods used for the purpose, each of which methods, however, can be accomplished in more than one way:

1. By adjusting the gate mask and lens.

2. By imparting to the film an extra movement independent of the feed movement.

3. By altering the feed so as to feed a longer or shorter length of film sufficient to compensate for the creep.

Centering the Film by adjusting the Gate Mask and Lens.

In order to keep the centres A, B, C, Fig. 196, of the picture, lens, and screen, in a right line, when the centre

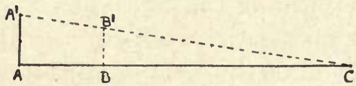


FIG. 196.

of the picture shifts from A to A′, the lens should receive a proportionate adjustment: $BB' = AA' \times \frac{BC}{AC}$. As, however, BC is very nearly equal to AC, it is sufficiently accurate if the lens is adjusted the same amount as the

gate mask. This method of adjustment is, perhaps, the simplest, and is used on many machines. The adjustment

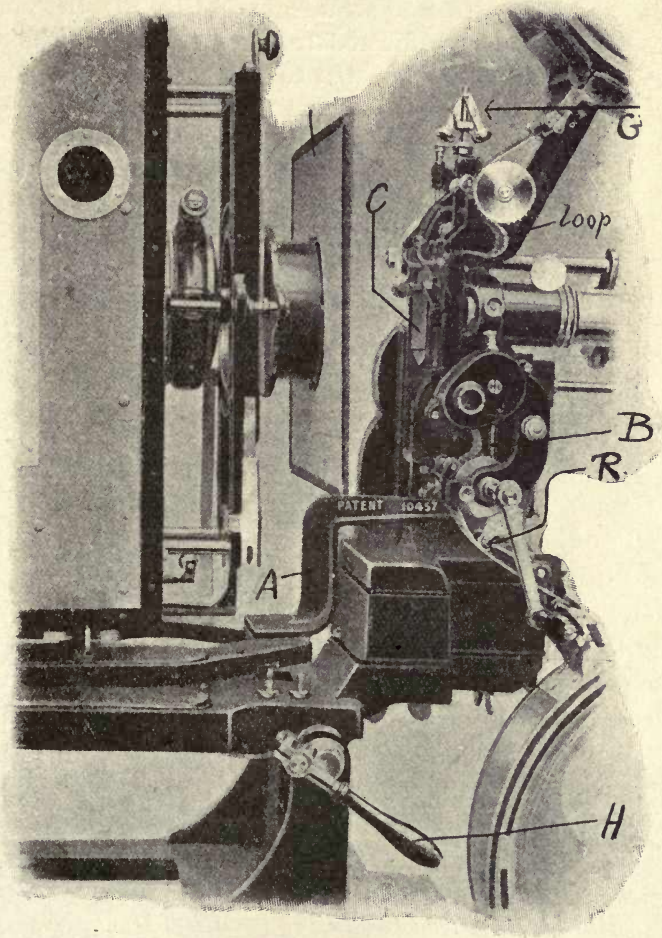


FIG. 197.

may be effected by rack and pinion, or by a pivoted lever, H, as in Figs. 184A, 184B. There must be a sufficiently large circle of illumination, x, x, Fig. 185, on the gate to

allow the adjustment, and the light does not remain on the line of centres ABC. To avoid the latter defect, the light and the condenser may be adjusted simultaneously with the gate and lens. In Butcher's Empire, Fig. 197, the parts are simultaneously adjusted from the handle H, which moves the arm A, connected to the base of the lantern

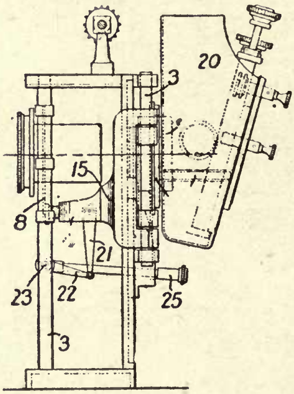


FIG. 198.

body, and also the rod B, controlling the mount carrying the lens and gate mask. In another machine, Fig. 198, the casing 15 carries the plate 8, supporting the lens and mask, the mounting for the condenser, and the casing 20 for the light. The various parts slide on uprights, 3, and the adjustment is effected from the lever 25 through the shaft 23 and links 22, 21.

Centering the Picture by imparting an Extra Movement to the Film Independent of the Feed Movement.

(*a*) The additional movement may be imparted by an adjustable roller, as in Hughes' Bio-Pictorescope, Fig. 199, in which the rollers *p* are adjustable by racks and pinions from handles R. This adjustment is also used in Wrench's

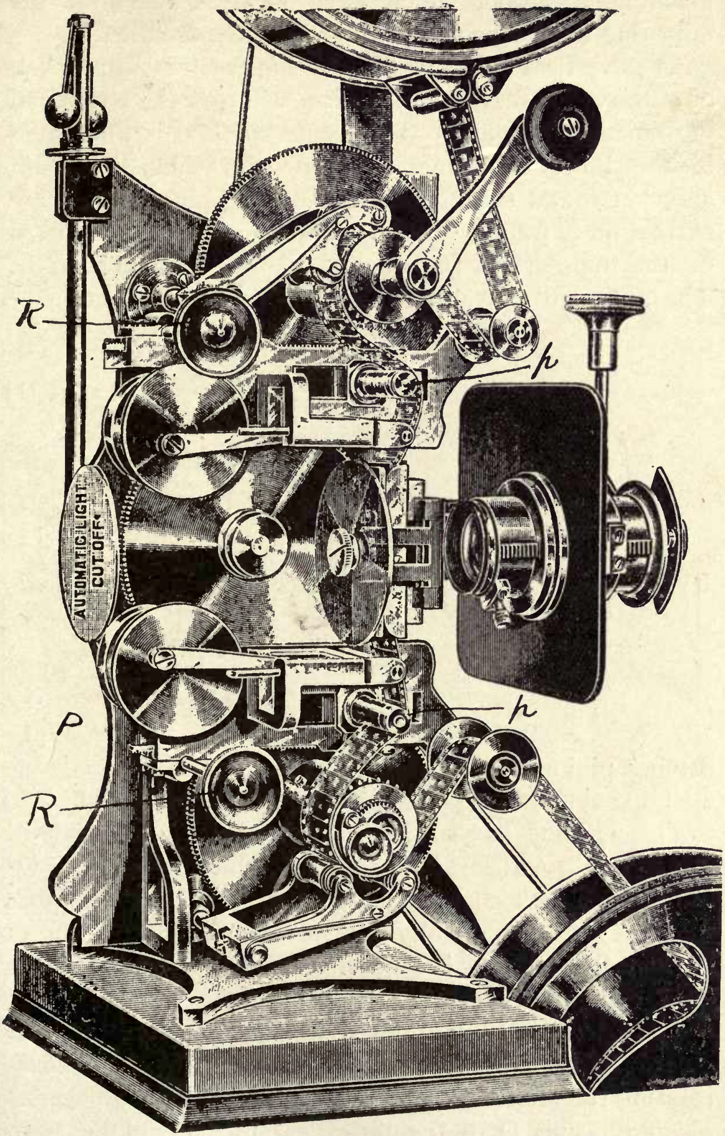


FIG. 199.

machine, Fig. 200, which is a dog-feed machine, the adjusting roller *f* being operated from the handle *l*.

(*b*) A vertical movement of the Maltese cross sprocket, or of the whole driving mechanism, will give the additional movement of the film. The former method is illustrated in the Power machine, Fig. 201, in which the film sprocket 6 and the intermittent driving pin-wheel 22 are carried on a framing carriage which is vertically adjusted on the main frame from a handle, H, through links L. The intermediate gear-wheel 38, gearing with the stationary

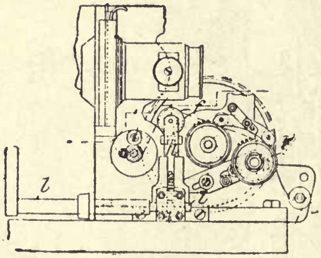


FIG. 200.

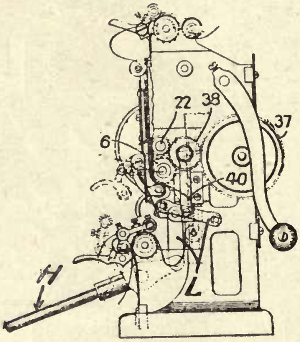


FIG. 201.

driving pinion 37 and the adjusted pin-wheel 22, is on a sliding support, 40, and is simultaneously adjusted.

This method is also illustrated by the Ernemann projector, Fig. 202, in which the driving mechanism, including the lower feed sprockets A and the Maltese cross sprocket C, are vertically adjusted on the frame M from the handle H. It will be seen that in this machine the driving spindle is also raised and lowered.

(*c*) In lieu of giving the feed mechanism as a whole a vertical adjustment, the same result can be effected by rotating the Maltese cross M, Fig. 203, and film sprocket S, about the axis O of the pin-wheel P. It will be seen, however, that while the Maltese cross remains in contact

with the periphery of the pin-wheel the step of the feed will be altered by any rotary adjustment of the cross, and in order, therefore, that the shutter shall mask the film during a shift there must be a compensating stepping adjustment of the shutter. A centering adjustment of this kind is used in one of Kamm's machines. The sprocket-

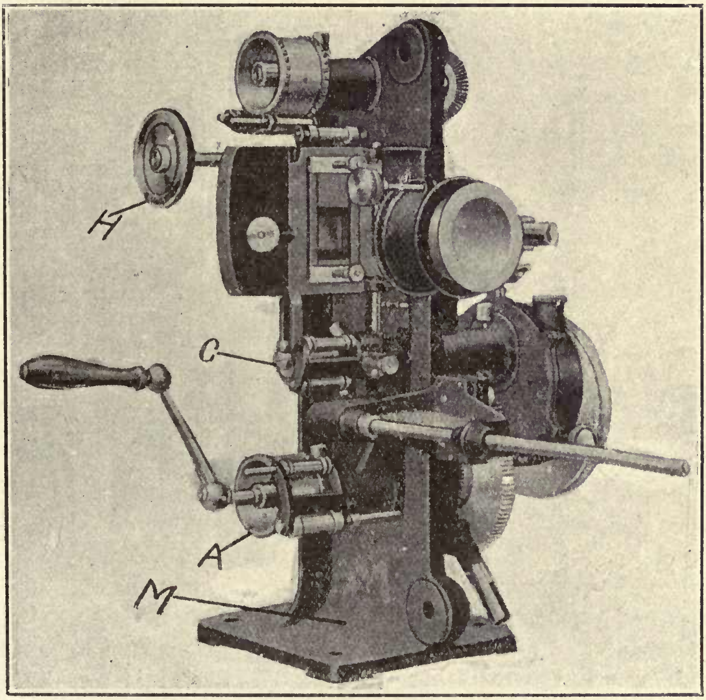


FIG. 202.

wheel is adjusted about the axis of the pin-wheel from a lever or handle behind the frame carrying the driving mechanism, and the shutter is simultaneously adjusted by means of a sliding bar, p, Fig. 204. This bar has relatively inclined slots, p^2, p^3, engaging respectively the stud n and a pin, p^4, on the disc o, carrying the shutter pinion j.

When the bar p is adjusted, the slot p^3 rotates the disc o by means of the slot p^2 and pin p^4, thereby causing the shutter pinion j to roll on the toothed wheel k by which it is driven.

(*d*) A fourth method of imparting an additional movement to the film is by giving an extra rotation to the feed sprocket in addition to the feed movement, and without moving its axis. This may be accomplished in several ways:

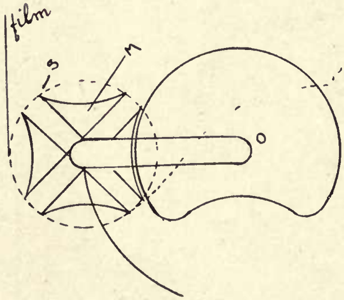


FIG. 203.

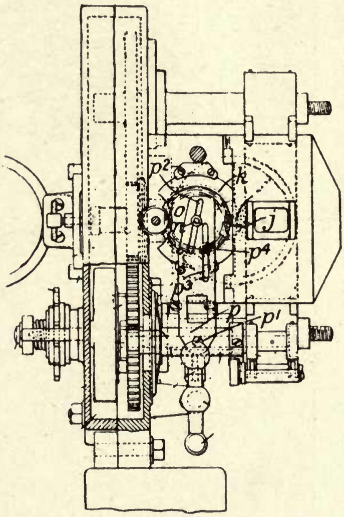


FIG. 204.

(i.) A direct rotation may be given to the sprocket-wheel. Fig. 205 illustrates one example of this method. The spindle of the sprocket f is formed with spiral slots, g, engaged by pins, i, on an axial rod, h, which is positioned between a cam, k, and a strong spring. By turning the cam k the axial movement of the rod h and pin, i, gives the additional rotation of the sprocket f. This method is very similar to that used in Maskelyne's Mutograph (see Fig. 100).

(ii.) In another method, illustrated in Fig. 206, the sprocket *a* is driven by differential gear, *i*, *m*, *j*, and the

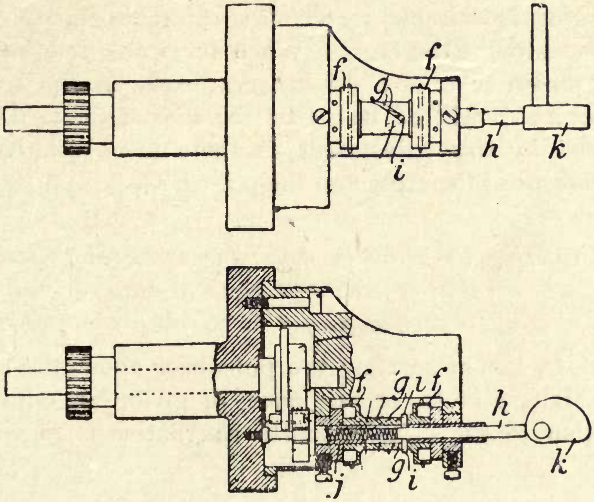


FIG. 205.

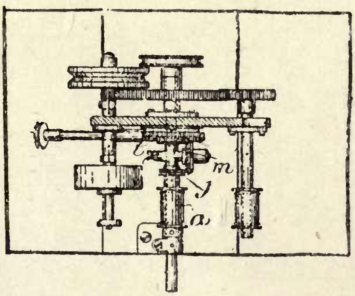


FIG. 206.

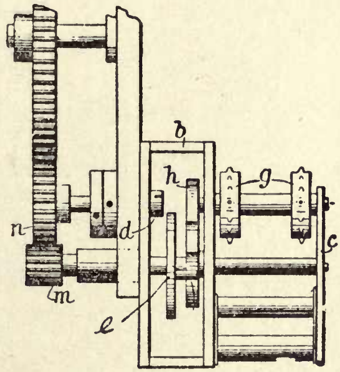


FIG. 207.

intermediate wheel *m* can be rotated round the axis of the sprocket, the rolling action giving the additional rotation to the sprocket.

(iii.) In a third method the pin-wheel *e*, Fig. 207, of a Maltese cross feed is adjustable about the axis of the Maltese cross *h*. The feed sprocket *g* and the cross are mounted in a frame, *bc*, which is rotatable about a pivot, *d*, coaxial with the cross. When the frame *bc* is rotated, the pinion *m* of the driving gear rolls on the toothed wheel *n*. It will be seen that the step of the feed is not altered by this adjustment as there is no relative displacement of the cross and the pin-wheel.

Centering the Film by modifying the Feed to feed a Longer or Shorter Length of Film to compensate for the Creep.

(*a*) In lieu of rotating the pin-wheel about the axis of the Maltese cross, or *vice versa*, or giving an additional rotation to the cross, a fourth alternative is to give an

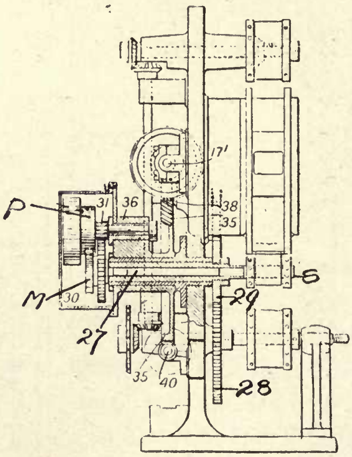


FIG. 208.

additional direct rotation to the pin-wheel. This is adopted in Mr. Hepworth's mechanism (Fig. 208).

The pin-wheel P is driven by the gearing 28, 29, 30, 31.

The pin-wheel P and the wheel 31 are supported in a mounting, 36, which can be moved round the axis of the wheel 30, which is loosely mounted on the shaft 27, carrying the Maltese cross M and film sprocket S. The adjustment of the mounting 36 is effected from the shaft 40, which is in gear with the toothed wheel 35 on the mounting. It will be seen that such adjustment causes the wheel 31 to roll on the wheel 30, thereby imparting a forward or backward rotation of the pin-wheel independently of its normal rotation. This independent rotation will also alter the step of the shutter. The simultaneous adjustment of the shutter is effected by gearing the wheel 35 with the casing 38 of the differential

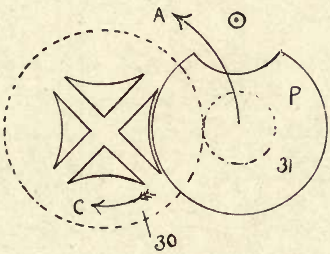


FIG. 209.

gear, included in the shutter driving train, the shutter being mounted on the shaft 17′. This mechanism has the somewhat curious feature in that it provides an unlimited adjustment of the film in either direction. If we keep the driving gear and wheel 30 stationary, it will be seen from Fig. 209 that, as the pin-wheel P makes one complete revolution about the Maltese cross in the direction of the arrow A, the cross would be rotated through one complete revolution—*i.e.*, equivalent to four shifts—were it not for the rotation of the pin-wheel about its own axis due to the rolling of the wheel 31. This rotation of the pin-wheel rotates the cross backwards in the direction C through a quarter-revolution for each

complete rotation of the pin-wheel on its axis. If, therefore, the gearing 30, 31, is so arranged that the pin-wheel rotates the cross backwards four times during a complete revolution about the axis of the cross, the position of the film will ultimately remain unchanged. The operator can thus turn the adjusting handle to the necessary extent in either direction without having to consider whether he has come to the limit of adjustment in either direction.

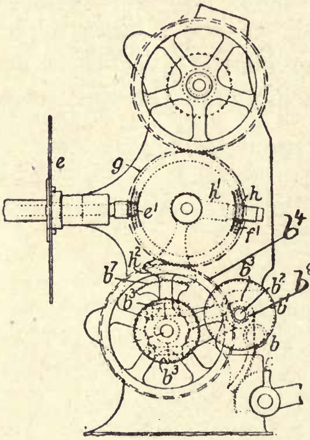


FIG. 210.

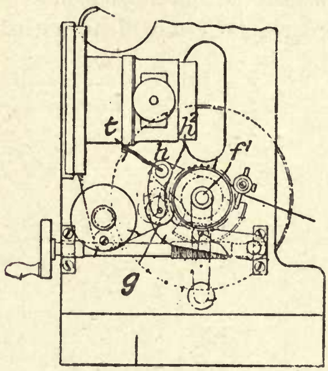


FIG. 211.

(*b*) Two other adjustments for dog-feed machines require notice.

(1) In Beard's mechanism (Fig. 210), the dog b is carried by two discs, b^1, the spindle, b^2, of which is mounted on a frame, b^3, turning on the axis of the driving wheel b^4. When adjusted by the sector c, the driven wheel b^8 rolls on the driving wheel b^4, and an additional rotation, backwards or forwards, can thus be given to the beater. To correspondingly adjust the shutter e, an intermediate pinion, h, of a different train, b^4, f^1, h, g, e^1, is given an additional rotation on adjusting

the frame b^3, thereby causing a corresponding additional rotation of the pinion e^1 of the shutter shaft. The adjustment of the pinion h is effected by the gearing b^7, h^2, which rocks the arm h^1 on which the pinion h is mounted.

(2) The feed may also be altered by drawing in or letting out the slack film between the gate and the take-up sprocket. In one of Kamm's machines, the roller g (Fig. 211), which presses the film on the sprocket, can be adjusted round the axis f^1 of the sprocket by rotating the arm h carrying the roller. To allow the film to be threaded easily, the arm is made in two parts, h, h^2, pivoted at t.

An alternative method is an adjustable roller, such as p in Hughes' machine (Fig. 199).

The Shutter and Flicker.

The objectionable phenomenon of flicker is traceable to the fact that the picture is periodically cut off from view—a state of affairs which, of course, does not obtain in natural vision. It must be remembered that, though persistence of vision insures the continuance of one image until the next image is received, yet the impression does not continue in its full force, and the general result is, therefore, a series of successive increases and decreases in the brilliancy of the picture as perceived by the eye. Furthermore, the decreases are gradual, whereas every fresh view is presented suddenly in full brilliancy.

There are, broadly speaking, four methods which have been tried or suggested for removing flicker:

1. By maintaining a constant illumination on the screen.

2. By synchronously switching the projecting light off and on.

3. By a sufficiently quick shift movement of the film to avoid the necessity of the shutter.

4. By special constructions and arrangement of the shutter.

1. *Maintaining a Constant Illumination on the Screen.*—One method, and a very early one, suggested by Acres in 1897, is to produce a series of views by alternately using two lenses, the views being arranged on the film in the order 1, 3, 2, 4, 5, 7, 6, etc., the film being moved behind one lens while the exposure is made with the second lens. In the camera, Fig. 212, the film is driven by two sprocket-rollers, A, A′, a loop, B′, being formed between them. A crank, F, drives a double-toothed rack, C, backwards and forwards, thus rotating the sprocket-rollers, which, however, can only turn in one direction, being prevented from moving backwards by a locking ratchet. Thus, in the illustration an exposure is proceeding with the left-

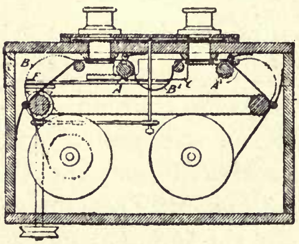


FIG. 212.

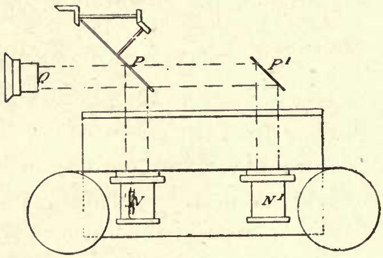


FIG. 213.

hand lens. As the slide C moves to the right, the sprocket-roller A will not be moved, but A′ will rotate and draw the loop B′ behind the right-hand lens. So soon as exposure with this begins, the rack moves back to the left, and now it is the sprocket-roller A′ which remains still, while A draws off more film from the loop B, and at the same time passes on sufficient film to re-form the loop B′ between the lenses. In the duplicate projector, Fig. 213, a parallel beam of light from the lens Q either passes through the objective N′ by reflection from the mirror P′, or is cut off by a rotating mirror, P, and transmitted from N on principles the same as those explained in connection with Figs. 86, 87.

A modification of this method, used by Mr. Friese Greene consists in duplicating the film and apparatus, using two films side by side, which are fed and exposed alternately. In both these methods, however, the alternate views are taken from adjacent points of view, and this must induce an apparent vibration of the foreground objects on the screen, and, indeed, there appears to be little advantage in using a duplicate system for obtaining the films unless it be so arranged that both systems work through one objective, as in Fig. 86, or at least from one point of view. This objection is obviated by another suggested method, consisting in using an ordinary single film and intermittently projecting a clear disc between the intervals of shift. This method also obviates any special modification in the camera or projector, apart from the necessary but simple modification of the shutter to make the alternate projections.

2. *Synchronously switching the Projecting Light on and off.*—This method is quite a recent one. In one modification the projecting light is switched on when the picture is in the gate, and extinguished while they are changed, for which purpose the projecting arc is intermittently induced by a circuit which includes a make and break contact controlled from the feed mechanism. An auxiliary lamp projecting a clear white disc may be switched on and off alternately with the projecting arc.

3. *Using a very Rapid Shift, and dispensing with a Shutter.*—This method was used by Wheatstone (see p. 17), and has been tried with modern Maltese cross projectors. It might be successful and efficient if the pictures were of uniform tint all over the surface—that is to say, if they were not pictures at all. As, however, high lights are a necessity in all lantern or other views, their continual presence gives rise to a "rain" effect, usually associated with damaged films. It must not be forgotten that a perception of this sort persists as well as any other; the eye

has no power of applying a physiological function to artistic impressions, and throwing it out of action in other cases. Still, the merits of this course of proceeding are purely relative, and, if the period of change is very rapid, there is no reason to doubt that with the majority of views a shutter may be dispensed with.

4. *Special Forms of Shutters.*—A medium course to dispensing with a shutter altogether is to modify it so as to neither entirely cut off the light during a shift interval,

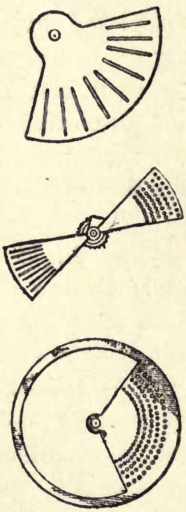


FIG. 214.

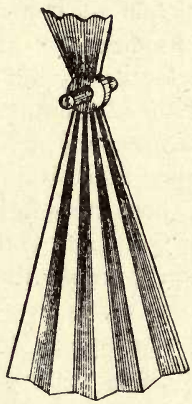


FIG. 215.

nor to permit the change of picture to be clearly perceived. The various means for this purpose include, (*a*) a shutter pierced with slots or holes, three types of which are shown in Fig. 214; (*b*) a translucent pleated shutter, Fig. 215; (*c*) a shutter with graded opacity, so as to gradually cut off the light, Fig. 216A; (*d*) giving short supplementary obturations during the time the picture is illuminated, by means of additional intermediate blades, A, Fig. 216B; (*e*) the use of a polarized beam of light which is rotated by electro-

magnetic action to such a degree that it cannot pass through the second prism, a method which, however, is hardly possible owing to the inevitable loss of light.

None of these devices, however, are perfectly satisfactory. They are essentially based on the theory of the persistence of vision, according to which, as explained in the first chapter, the action of the light on the retina

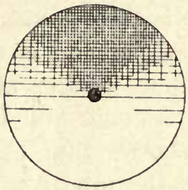


FIG. 216A.

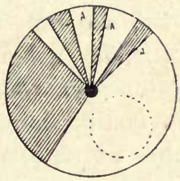


FIG. 216B.

gradually dies down when the picture is cut off, whereas when the light is projected on the screen the action on the retina is very sudden. Mr. Proszynski, who has extensively investigated the subject of flicker, has put forward the somewhat startling and revolutionary view that the suppression of flicker has nothing to do with the phenomenon of persistence of vision, and, further, that the continuity of cinematographic vision is quite illusionary, and, indeed, something which does not exist. The action on the retina can be represented graphically. In Fig. 217 the light is intermittently projected at times represented by the points t, u, v, and lasting for the time intervals tt', uu', vv'. The intervals $t'u$, $u'v$, represent the intervals during which the shutter acts. The dotted curves represent the

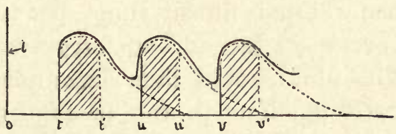


FIG. 217.

variation in the intensity which would be produced on the retina by the separate projections, whilst the full lines represent the actual variations in intensity produced by the rapid alternations. The area of the shaded parts represents the total effect on the eye. Mr. Proszynski attacks the problem of flicker on the basis that the eye cannot directly measure any period less than $\frac{1}{40}$ second. A flash or interruption of light lasting $\frac{1}{100}$ second will seem to the eye the same as one lasting $\frac{1}{40}$ second. In other words, for a normal person $\frac{1}{40}$ second is the limit of perception. If, therefore, there are two or more illuminations lasting longer than $\frac{1}{40}$ second, and following one another at regular intervals shorter than $\frac{1}{40}$ second, say $\frac{1}{50}$ second, we cannot conceive the interruptions, and

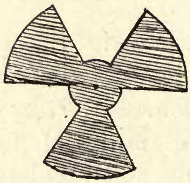


FIG. 218.

the effect will be that of a constant light. The shutter in Fig. 218, when rotated fifteen times per second, gives alternations every $\frac{1}{45}$ second, or forty-five alternations a second. The film should thus accomplish a shift in $\frac{1}{90}$ second, corresponding to the passage of one blade across the lens. With the ordinary Maltese cross having the four slots, the shift interval is one-fourth of the total interval—*i.e.*, is $\frac{1}{60}$ second, assuming one shift per revolution of the shutter. With this combination only two-thirds of the change movement of the film would be masked. With the above shutter, therefore, the intermittent mechanism should give a shift interval of one-sixth the total interval in order that the shift may be completely masked. The method often adopted where

the shift interval is not quick enough is to slightly enlarge one of the blades of the shutter sufficiently to mask the shift. This, however, destroys the regularity of the alternations of light and dark, and is at best a makeshift.

Other alternatives for obtaining regular obturations of $\frac{1}{40}$ second or less may, of course, be used with equally satisfactory results. It is, for example, possible to obtain the regular obturations of $\frac{1}{40}$ second or less by other forms of shutter, such as a single-bladed shutter, or one with two blades, or with a cylindrical shutter, Fig. 219A, or a cone-shaped shutter, Fig. 219B, as used on the Motiograph.

The shutter is usually put at or near the position F^2,

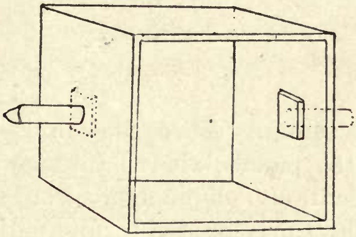


FIG. 219A.

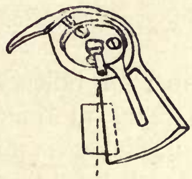


FIG. 219B.

Fig. 185, where the optical beams cross, so that the whole area of the screen may be illuminated and darkened simultaneously, or as nearly so as possible. Where the shutter is not in this position, the blades should be shaped as in Fig. 220, so that the edges travel across the screen parallel to the margin of view.

A shutter in front of the lens has to be somewhat large. In many machines the shutter is situated near the film, in which position it is possible to use a much smaller shutter. Mr. Kamm has recently suggested putting the shutter behind the film gate, and to use fan blades. This arrangement serves not only to cut off a great amount of heat from the film during the actual obturations, but also

creates a draught of air on to the film and gate, thereby considerably lessening the liability to fire.

In connection with the above theories of flicker, an old device (Fig. 221) of M. Gaumont, known as "la grille," and consisting of a black fan pierced with a

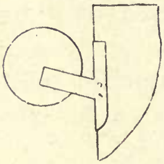


FIG. 220.

FIG. 221.

number of holes, is interesting. When the fan is put into rapid motion, and the picture viewed through the holes, flicker is almost entirely eliminated. The suggestion here is that the effect may be due to alternations of light oftener than $\frac{1}{40}$ second.

FIRE-PREVENTING AND SAFETY DEVICES FOR PROJECTORS.

The chief source of danger in cinematographic work arises from the inflammability of the celluloid films. If proper care is exercised in handling these films there should be little or no danger, and far more serious consequences are likely to result from any panic amongst the audience than from the fact of some film having caught fire. The regulations under the Cinematograph Act (see Chapter IX.) must be observed before any exhibition can take place in which inflammable films are used, and the licensing authorities may supplement these by addi-

tional regulations. The regulations under the Cinematograph Act deal chiefly with the buildings themselves, exits, fire appliances, the handling of films, lighting, and licences. There are, however, three—namely, Regulations 6-8—which deal with the construction of projectors.

When the projector is running at full normal speed, the individual pictures are not in the gate long enough to be ignited by the condensed beam of light from the lantern. The danger arises if the machine slows down and the film is left exposed in the gate. The gate itself, of course, gets hot, but the heat is largely conducted away, and the part of the gate in contact with the film can be isolated from the heated portions by asbestos.

The various devices designed to prevent the film firing in the projector, and to prevent fire spreading, fall under different heads, according to the purpose directly in view.

Devices for screening the Film from the Heat of the Projecting Light.

The idea and use of a heat-absorbing medium between the light and the film was one of the earliest methods suggested. Lumière's original plan was to use a flask, B, of water, Fig. 222, which also acted as the condenser.

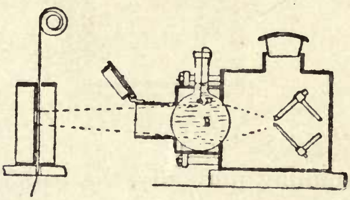


FIG. 222.

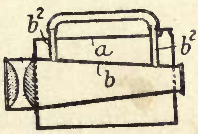


FIG. 223.

A piece of carbon, D, is suspended in the water to draw off the gases set free by the gradual heating of the water. The water-flask does not, however, prove a sufficiently good condenser, and with a strong light used the water

should soon be at boiling-point. This difficulty arises even when circulating systems are used. Mr. Newman has proposed a long conical water-tube, *b*, Fig. 223, surrounded by a water-trough, *a*, fitted at the front of the condenser, and with externally connected filling and expanding tubes, b^2. A cold-water circulating system through the trough would further cool the tube *b*.

Devices comprising an Automatically-Controlled Shutter which comes into Action if the Machine slows down, or in Some Cases if the Film breaks.

Practically speaking, all modern machines are fitted with a shutter of this description, and there are numerous ways of adapting such shutters. In many cases the shutter is opened by the action of a centrifugal governor driven from the driving shaft of the machine. Fig. 224 illustrates one of the earliest arrangements. The shutter *e* is controlled by the governor *i* on the driven shaft *c*.

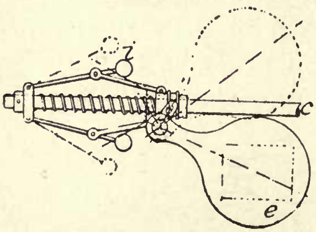


FIG. 224.

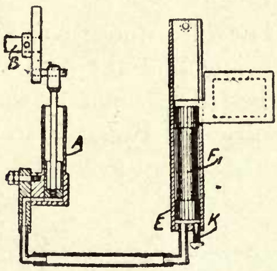


FIG. 225.

When the projector is running normally, the balls *i* fly outwards against the action of the spring *f*; if the projector stops or slows down below the safety limit, the spring *f* draws the balls in, and drops the shutter. In other projectors the shutter closes under the action of gravity. A pneumatic control, devised by Mr. Prestwich in 1899, is interesting. The driving-wheel B (Fig. 225)

of the machine works a pump, A. The cylinder E has an adjustable outlet, K, and is adjusted so that when the machine is working normally the pressure is sufficient to raise the piston F which carries the shutter.

It will be seen that with these arrangements the safety shutter only acts when the speed of the machine is reduced below the safety limit. It is possible, however, for the film to break below the gate, and leave the film stationary in the gate while the machine continues to run at full speed. To provide against this contingency, the film may control additional safety devices. In Butcher's Empire, a light roller, R (Fig. 197), rests on the film, and should the film break the roller drops and automatically operates a brake which stops the machine, thereby automatically causing the release of the safety shutter, which, when the machine is running, is held open by the centrifugal governor G. In other arrangements the shutter is held open by an electromagnet, the current through which is broken if the machine slows down or if the film breaks. Another arrangement is to hold the safety shutter open by a catch, and to use the film as an insulator between two contacts, so that if the film breaks, the current in the completed circuit energizes an electromagnet which releases the shutter. The current may, in addition, be utilized to switch off the projecting light, and, if the machine is motor-driven, to stop the motor also.

Preventing the Film firing by directly cooling the Film in the Gate.

This may be done by directing the current of cold air or gas, that will check combustion, on to the film. A recent alternative, proposed by Mr. Kamm, is to shape the blades of the shutter as a fan. The shutter may be placed behind the gate so as to screen the film from heat during the obturations, as well as fan the film.

Devices for preventing the Fire spreading along the Film.

To confine the fire to the film gate, it has been suggested to provide a pair of rollers, N, N^1, N^2, N^3, Fig. 226, at the top and bottom of the gate; also a pair of spring-controlled wedge clamps have been suggested which can be released by hand, or automatically by the burning of a strip of inflammable material used to hold them in operative position. Another device is the provision of two tubes, 12, Fig. 227, of fire-proof material on both sides of the gate, which are designed to prevent any film which may accidentally unroll from falling across the projected

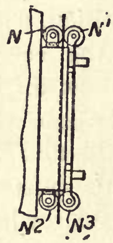


FIG. 226.

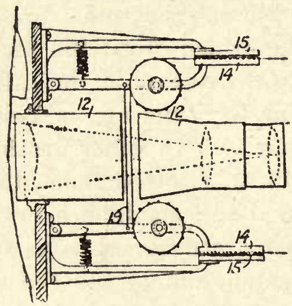


FIG. 227.

rays and becoming ignited. The film also passes through two shoots, 14, 15, above and below the gate. The members 14 are carried by spring-operated levers normally held apart out of action by less inflammable connections, 19. The film is thus clamped at both sides of the gate if the picture in the gate becomes ignited. Such devices are not so common as other analogous devices for preventing the fire spreading into the spool box, and which are necessary to satisfy Regulation 7, cited above.

The spool box is often provided at some point adjacent to the slot with a spring or weight actuated slide or clamp, or one automatically actuated on the ignition of the film, or of a fuse suitably positioned so as to catch fire if the

film ignites at the gate. It has also been proposed to extend the film-channel right to the gate, and to include cutting-knives for automatically severing the film at the mouth of the spool box or the end of the guide channel.

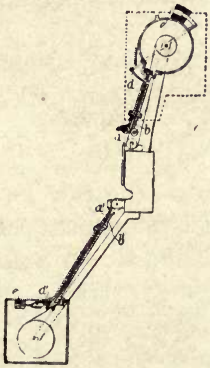


FIG. 228.

In one such arrangement (Fig. 228) the ends a, b, and a^1, b^1, of the film channels, are connected to solenoids, e, e^1, respectively. The film acts as an insulator, but if it becomes ignited the solenoids operate knives d, d^1, to sever the film.

Devices for extinguishing the Fire.

In one of these a water-spray, or extinguisher, is situated over the spool box, and is automatically operated by an ignited fuse in case of fire. In another device the apparatus is lowered into a box which is closed by a light, tight lid, with the object of stifling the fire.

Devices comprising Means for automatically switching off the Projecting Light.

Such a device was provided on a very early automatic living-picture apparatus displaying an endless band, and designed by Mr. Hepworth (see British Specification

11,923 of 1897). A jockey roller is provided, so that if the film tightens by reason of any entanglement or accident, the roller rises and breaks the main supply circuit. In other devices the film normally insulates two contacts controlling various switches, and an alternative lighting circuit. Such connections may even extend to the emergency exits, so as to automatically unlock these.

Film Manipulating and Housing.

In all projection work, the rule for obtaining a correct image on the screen is film-side upside-down to the condenser. Placing the film-side towards the projecting lens reverses the picture—not a serious matter as a rule, unless a well-known landscape or any lettering appear on the scene. But this error is apt to cause strange effects in other ways. For instance, at one entertainment Ranjitsinhji was shown batting in grand style—left-handed! Not a likely experiment for an Australian test match, it must be confessed!

When the spool has been used, it will require rewinding backwards before it can be used again. Some machines, such as Hughes's Bio-Pictorescope, have been made with a double-feed mechanism, and the operation of reversing in this case consists simply in reversing the projector. This projection in a reversed direction is sometimes used to give "trick" films. A reversed diving scene, for instance, will show an existing splash which gradually dies down, and from which emerges a man, feet uppermost, who in this attitude makes his way to the diving-board, from which he should have started. The same effect can, of course, be obtained by running the film directly through an ordinary machine without rewinding the film, and using a reversing prism to erect the images which otherwise would be upside-down.

To rewind the film it is more usual to use a separate

rewinder, which is a comparatively simple machine compared with the projector. Fig. 229 illustrates Wrench's rewinder. The rewinding spool A is driven by a ratchet and pawl, and can run on as a free wheel when the winding handle H is stopped. A brake, C, is caused to act on the spool B by a backward rotation of the handle H. This arrangement enables the film periodically to be drawn taut on the spool A, as well as serving as a brake to stop the rewinding.

Various methods of spooling the film have been sug-

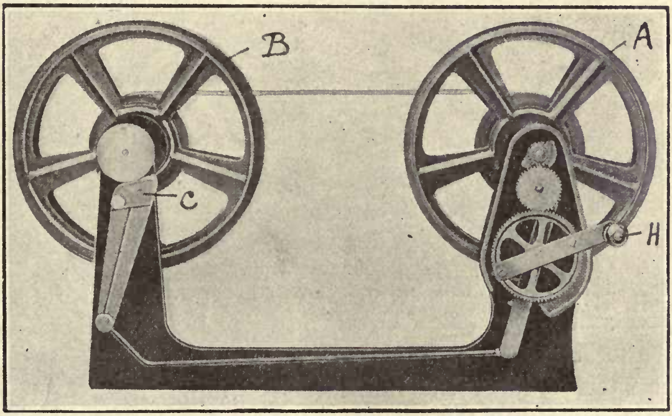


FIG. 229.

gested with a view to avoiding the necessity of rewinding the film; but for general convenience and utility the use of an ordinary spool probably offers the greatest advantages. In one method the store spool is to lie flat; the film is drawn from the centre, and after passing through the machine, is wound in the ordinary way. There does not appear to be anything impracticable in this method, but it does not appear to have found its way into use.

If a film breaks while running through the projector—unfortunately not an uncommon occurrence—it is, of

course, impossible to mend it permanently before proceeding, and a temporary join is necessary. This is sometimes done by a pin or small clip, sometimes it must be admitted by merely wetting the film to make the broken end adhere temporarily to the film roll. A spool clip which avoids in any way tearing the film consists of a pin, B (Fig. 230), which can be drawn through the clamping screw A, and

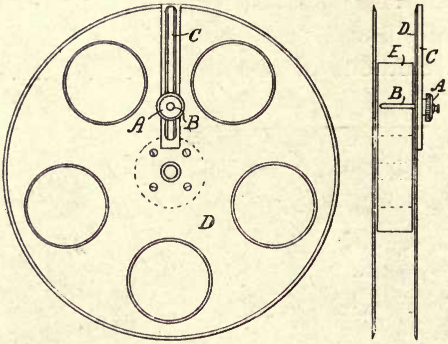


FIG. 230.

this clamping screw slides towards and away from the spool axis along a slot, C, on the spool D. The loose end of the film is pressed on the existing core E (whether the spool core or the film already wound) by the pin B, which is clamped in position by the nut A. If a subsequent break occurs, the pin B can be withdrawn and reinserted higher up the slot to reclamp the broken end.

Stereoscopic Projection and Other Methods of obtaining Solidity and Relief.

So far reference has been made only to ordinary exhibiting, in which the pictures are projected on to a flat screen. The term "Moving Pictures" has been extensively used, and if "motion" effects were all that were desired, it could be safely asserted that a very high degree of perfection has been attained. For a good "Living"

Picture, however, it is necessary to combine the perception of solidity and relief with that of motion. Between ordinary still-life photographs there may be considerable differences in the effects of solidity and relief conveyed to the eye, and the same is true of Living Picture films. There is, however, a marked difference between the impression obtained from the most perfect single picture and from a stereoscopic pair when viewed in a stereoscope, and it is a matter of common experience that the impression of solidity and relief is often much more intensified with a stereoscope than is conveyed by the actual view.

The term "stereoscope" is derived from two Greek words, signifying "solid" and "relief," and, etymologically speaking, a stereoscopic picture is one which to the eye conveys the impression of solidity. The term has, however, come to have a narrower meaning, and as ordinarily used implies the reproduction of binocular vision. For this reproduction two conditions have to be observed—(1) that to each eye is presented a picture which differs from its companion to the same extent as two pictures taken from two relatively adjacent standpoints at the same distance apart as the eyes; and (2) that these dissimilar pictures are made to appear at one place to the eye so that the impressions merge into one picture. The latter purpose may be accomplished with a stereoscope or by projection. The attempts made to get the simultaneous impressions of solidity, relief, and motion, date as far back as 1853, and the earlier methods have already been noted in Chapter II. The following suggestions, amongst others, have also been made for living-picture projection: (1) Double projection and a viewing stereoscope for each observer has been suggested. (2) The two films are coloured in complementary colours and viewed through differently coloured glasses, so that each eye may select its proper picture. This is the method used for the well-

known plastograph still-life pictures. The pictures need not be separate, but may overlap to save space. A recent method for combining the two components in one picture is interesting. The component images are produced on a two-colour screen, the colours of which are complementary, or almost complementary, and so that the elements of one component picture are only situated for example on the red elements R (Fig. 231), whereas the elements of the other component are only situated, for example, on

FIG. 231.

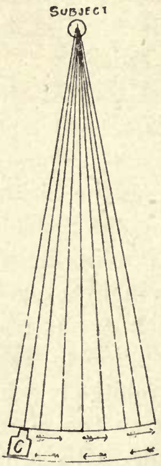


FIG. 232.

the green elements G. It will be seen that the components are not whole components, but sections of a component, the two sections just filling the picture. The photograph or projected picture is viewed by coloured spectacles, the glasses of which are correspondingly coloured complementary to each other, so that each eye picks out its own component. (3) The use of polarized light for projecting the pictures has been suggested, with viewing analyzers relatively crossed so that each eye selects its own picture. (4) To avoid the use of two films, pictures may be taken

from adjacent standpoints alternately on to one film. This may be done by using two objectives and an auxiliary optical system, or by oscillating the camera transversely. The latter alternative, suggested by Mr. Theodore Brown, involves a considerable vibration of the camera, but admits of a simplified modification, consisting in oscillating the camera C more slowly upon an arc, as illustrated in Fig. 232. Demonstrations showing the effect of solidity and relief with this method were given before the Optical Society in 1904. The effect is not really a stereoscopic one, but is what might be called a "panoramic" one. The same effect is produced where a film is taken from a moving vehicle, and is due to the fact that the successive pictures are taken from successively adjacent standpoints.

Such methods as the foregoing have not as yet come into extensive use, owing no doubt to the practical difficulties and cost involved in duplicate apparatus, or supplying each observer with a separate viewing apparatus. Also, where pictures are taken alternately from adjacent positions and projected alternately without special viewing instruments, there is the liability to a vibration of the foreground objects, which it is apparently impossible to avoid.

Effects of solidity and relief have been obtained by other methods and involving other principles.

Pepper's Ghost will need no introduction to the reader, who will no doubt also be familiar with the methods by which the spirit is made to appear. Instead of employing living persons, it is possible to so utilize a living-picture film that the images on the film appear to walk about the stage like ghosts, with the difference, however, that as reality is aimed at, there is no attempt to produce a ghostlike appearance. Mr. Theodore Brown has specialized in these productions, and one of these methods is used to produce what are known to the general public as "Kino-

plasticon" pictures. Fig. 233 reveals the secret. It will be seen that, instead of a shadow of a living person being projected on the translucent screen F, which would be done to produce a real ghost, the living-picture film is projected on to this screen, and the projected images appear to the audience in the auditorium I, to be at or about the position J on the stage, the effect being due to reflection from the transparent mirror A. As, moreover, this mirror is transparent, the stage scenery is also seen, and the effect is that of real persons moving on the stage. The films used have to be specially taken. The subjects are posed against a black background or tunnel lined with

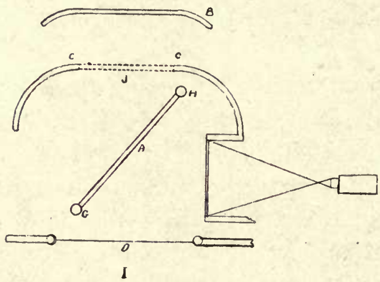


FIG. 233.

black material. The subjects are dressed in light costumes, so that the resulting positive film pictures give white images surrounded with a dense background, almost entirely or absolutely impervious to light. Thus, only the transparent images will be projected, and these only will be seen by the audience. The size of the picture area on the screen is so adjusted that when the artist goes out of the field of view, the point at which the exit is made corresponds with that occupied by the edge of the scenic wings C, with the result that the artist appears to go behind the real wings, and also to make his or her appearance from behind the wings. The appearance of the artists walking towards and away from the front of the

stage is due to the varying size of the figures on the film, and these effects are carefully arranged for by photographing the original actors on a studio floor with a rake corresponding to the rake of the theatre stage floor.

The popularity of the Scala during the time of these exhibitions—as, indeed, at all times for that matter—is sufficient evidence both of the attractiveness of these effects and of the possibilities of these methods of exhibition. There are, however, certain drawbacks in all methods where an indirect view of the projecting screen is used, such as in the method just described, where the

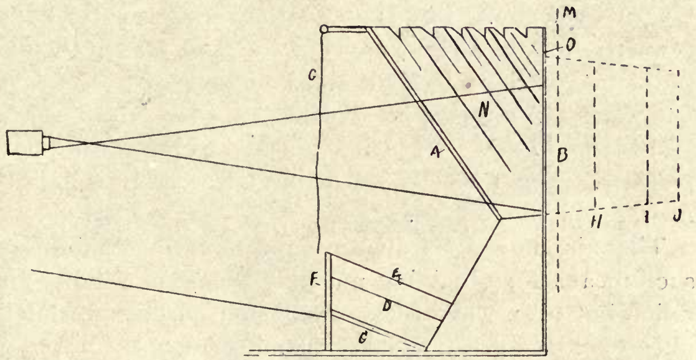


FIG. 234.

image is seen by reflection from the mirror A. The definition of the visible image is impaired by reason of the fact that there is a reflection from both surfaces of the mirror, thereby producing a double image. This drawback is not very great so long as the observer is fairly in the centre of the auditorium. Another drawback is the large amount of light required for projection, owing to the large amount of light lost both at the screen and by the reflection from the mirror. A third drawback arises from the large amount of stage-room required both for housing the mirror and the projector and screen, which

have to be kept from view. There is also the serious item of the mirror itself, which in the Scala measures something like 18 feet by 16 feet. To avoid some of these drawbacks Mr. Brown proposes to project the film on a screen in the ordinary way, either from the front or back of the screen, and to obtain the stage scenery by reflection. One such method, devised more especially with a view to easy adaptation to existing picture palaces, is illustrated in Fig. 234, which shows a sectional view. The stage setting is positioned at C, D, E, below the level and in front of the screen O on which the pictures are projected. It thus occupies part of the space usually appropriated for the orchestra. The stage setting is seen by reflection from the mirror A, and appears to be at H, I, J, behind the actual back wall M of the building. The screen O and mirror A are mounted with collapsible bellows, N, and both fold down when it is desired to project ordinary pictures. The name of "Cinelife" has been suggested for these picture effects.

There is, indeed, hardly any limit to the possibilities of such means for obtaining not only effects of solidity and relief, but also, where desired, illusion effects. Hamlet's ghost will be a greater reality than ever.

Miscellaneous Methods of Exhibiting.

In addition to theatre exhibitions, animatography has struck several by-paths. Commercial energy has, for example, seized upon the Living Picture for purposes of advertisement. Processes of manufacture, advertisements of health resorts, glimpses of scenery on "unique tours," the inducements which colonial life can offer, have, amongst many others, been the subjects of living-picture films.

Penny-in-the-slot machines have also been devised. The Kinetoscope was modified to render the scene visible to several observers. In another of these machines, Joly's

Photozootrope, the picture-band was run past several eye-pieces, and illuminated by a central light and slotted drum. A portable peepshow, designed by Mr. Hughes, is seen in Fig. 235. The picture is thrown on a proscenium at the inner end of a box provided with several eye-pieces.

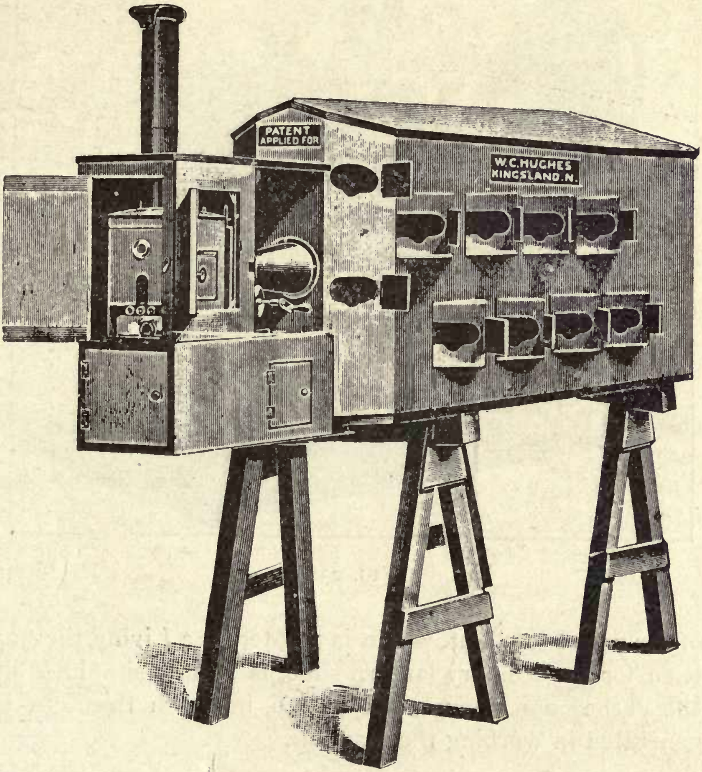


FIG. 235.

An ordinary projector can be used, and the structure is adapted to be easily taken to pieces and re-erected.

A recent development—one as yet in comparative infancy—is the "Home" cinematograph. The Living Picture is almost surely destined to vie closely with the

ordinary lantern for home and private entertainments, and many makers now specialize in apparatus simplified to the utmost limit for such purposes. The problem

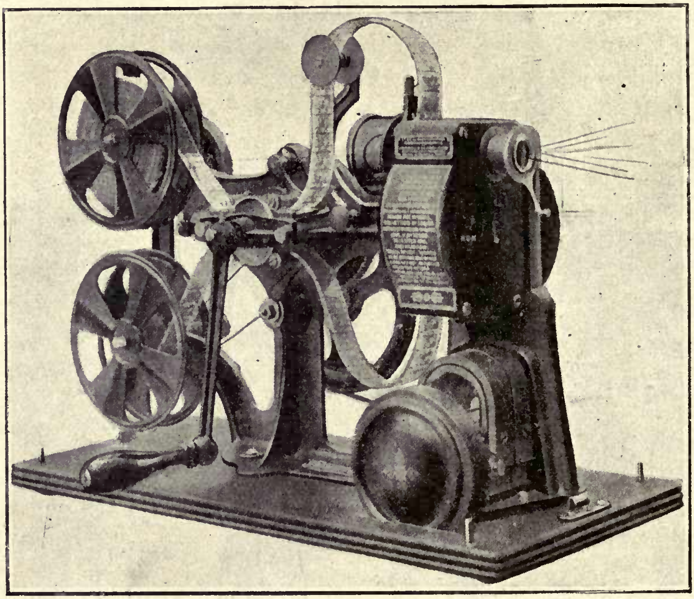


FIG. 236.

of the necessary light, which is greater for a Living Picture than for an ordinary lantern-slide, is greatly simplified in the Pathescope, shown in Fig. 236, in which the light is generated in working the machine.

CHAPTER VII

COLOUR CINEMATOGRAPHY

Principles of colour photography—Additive methods—Subtractive or superposition methods—Kinemacolour—Chronochrome.

PRINCIPLES OF COLOUR PHOTOGRAPHY.

HOWEVER perfect and perfectly executed a black-and-white photograph may be, and even if toned in the various art tones now possible, it leaves something to be desired if the attractiveness of the object or view lies in its colours. Accordingly, apart from the methods of colouring films by hand and machine described in a previous chapter, the efforts of photographic scientists have from the earliest times been directed to the reproduction by photography of the colours seen by the eye, and as projected on the focussing screen of the camera. In the absence of a sensitive plate which will directly reproduce the colours projected on it, recourse must be had to indirect methods, and Clerk Maxwell, as early as 1861, showed how it could be done. Preceding him, Isaac Newton had demonstrated that ordinary white light consisted of a large number of different coloured lights which could be separated by a prism. On the theory that light is an undulation, then, as there are undulations of every different period from one end of the spectrum to the other, there are an infinite number of kinds of light in the spectrum, each of which is identified with a particular wave-length, and is therefore a pure colour—that is, is not compounded of two or more colours. Newton also showed that the different colours

of the spectrum could be recombined to reproduce the original white light. What was even more significant was that the white light could also be reproduced by a suitable combination of the colours from particular parts of the red, green, and blue-violet portions of the spectrum. Also, different colours could be obtained from different combinations of these three colours. Yellow, for example, could be obtained from red and green, and, indeed, all the colours of nature can be reproduced and imitated by suitable combinations of these three—red, green, and blue-violet—coloured lights, which are from this fact called primary colours. No theory of the nature of light provides any explanation of these facts, and accordingly an explanation was sought for in the constitution and function of the eye. Young's theory of colour vision is that the eye is provided with three sets of nerves, each of which is extremely sensitive to one of the three primary colours, and in a much less degree to the other two. The action of the light of any colour on the eye is quite independent of the wave-lengths contained in the colour. The impression depends entirely upon the extent to which each of the three nerves are affected. The pure yellow of the spectrum containing only one wave-length will affect the red and green nerves in just the same way as yellow compounded of red and green and containing probably several wave-lengths. If, then, we can reconstitute the colours of a picture in terms of the three primary colours, by suitable combinations of these colours, the effect to the eye will be the same as the original picture. Clerk Maxwell showed how this could be done, and how the results of Newton's researches and Young's theory of colour vision could be applied to photography.

To take Maxwell's own description: "Let a plate of red glass be placed before the camera and an impression taken. The positive of this will be transparent wherever the red light has been abundant in the landscape, and

opaque where it has been wanting. Let it now be placed in a magic-lantern along with the red glass, and a red picture will be thrown on the screen. Let this operation be repeated with a green and a violet glass, and, by means of three magic-lanterns, let the three images be superposed on the screen. The colour of any point on the screen will then depend on the corresponding point of the landscape; and, by properly adjusting the intensities of the lights, etc., a complete copy of the landscape, as far as the visible colour is concerned, will be thrown on the screen. The only apparent difference will be that the copy will be more subdued, or less pure in tint than the original. Here, however, we have the process performed twice—first on the screen, and then on the retina." It is in this method assumed that the sensitive plates used for the colour images are equally sensitive to rays of every colour—*i.e.*, are panchromatic. To obtain a plate of this character is, however, more easy to assume than to accomplish. Maxwell did, however, obtain the earliest colour reproductions by this process. Such processes, in which the projections of three component images of the red, green, and blue in the picture are added, are known as additive processes. If now we go a step farther, and suppose that we have three living-picture films in lieu of Maxwell's single images, and that these are run through three projectors simultaneously, and the projected pictures superposed on the screen, we should obtain a Living Picture in colours. Unfortunately, the direct application of Maxwell's method is attended by many difficulties; but before dealing with these and the ways of avoiding them, it will be convenient to briefly describe other processes.

Subtractive Processes.—The foregoing method of adding colours by adding the projections of coloured lights must be clearly distinguished from methods which involve mixing pigments, or combining two or more filters and passing a beam of light through them. A very different

effect would, for example, be obtained if, instead of separately projecting the red, green, and blue-violet images produced by Maxwell's method, these were united together in register and used in a single lantern. The picture would be far from resembling the original. We can, it is true, imitate almost any colour by a suitable mixture of the three fundamental colours of artists—carmine (pink), chrome-yellow, and blue (prussian blue)—and these three colours are referred to by artists, and are popularly known as primary colours. The colour of a mixture of pigments is, however, very different from a true mixture of the colours of the separate pigments. Helmholz showed that when light falls on a mixture of pigments, part of it is acted on by one pigment only, and part of it by another; while a third part is acted on by both pigments before it is sent back to the eye. The two parts reflected directly from the pure pigments enter the eye together, and form a true mixture of the colours; but the third portion, which has suffered absorption by both pigments, is often so considerable as to give its own character to the remaining tint. This is the explanation of the green tint produced by mixing most blue and yellow pigments. The process is one of subtraction. The yellow pigment absorbs most of the blue and violet of the incident white light, reflecting the red and green, the combination of which is seen as yellow. The blue pigment, however, absorbs most of the red and yellow, whilst also reflecting the green. As the result, the green is the preponderating colour which reaches the eye. The amount of yellow and blue from the individual pigments which reaches the eye is very small compared with the amount of the light which suffers absorption by one or other of the pigments. This difference between the additive and the subtractive method of adding colours (to use an Irishism) is also illustrated in the following way: If we take three lanterns and project three discs of light partly

overlapping, as shown in Fig. 237, and insert in each lantern a coloured filter, one coloured red, another coloured green, and a third coloured blue-violet, the result on the screen will be the colours indicated. This illustrates the addition of coloured lights. If, on the other hand, we use one lantern, and take three circular discs coloured yellow, pink, and blue, with the three fundamental colours of the painter, and partly superpose the discs, as illustrated in Fig. 238, the result will be as indicated, and the black centre illustrates the result of subtracting all the colours in the white projecting light by one or other of the filters. The white patch in the centre of Fig 237, on the other

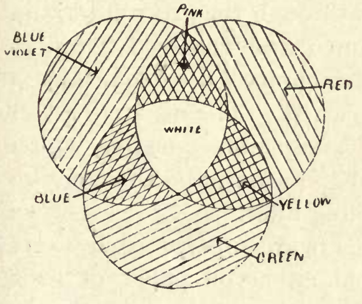


FIG. 237.

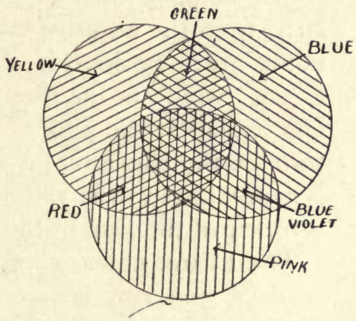


FIG. 238.

hand, illustrates the result of adding the colours of the filters, if the colours are the primary colours—red, green, and a blue-violet.

The fact that it is possible to imitate almost any colour of nature by a suitable combination of these pink, yellow, and blue pigments suggests, however, that it should be possible to reconstitute the colours in a picture by three component images in these colours. The method of doing this was accomplished by a French scientist, Ducos du Hauron. The process is broadly as follows: Three negatives are taken, as in Clerk-Maxwell's additive process, through red, green, and blue-violet filters, which

respectively pass the red, green, and blue-violet components of the light passing through them. The negative taken through the red filter will have an image wherever the red light has acted. The absence of image corresponds thus with the component light stopped by the red filter. The positive from the red negative will thus be a record of this subtracted component, and constitutes what is known as the minus-red positive. Now, when red is subtracted from white light, the result, known as the "complementary" colour, is blue-green, approximately the primary blue of the artist. The minus-red positive is therefore stained or coloured in this colour, the dye or colour being known as the "minus-red" colour. Similarly, from the negative taken through the green filter, the minus-green positive is obtained and coloured "minus-green," which is the "complementary" of green, and is approximately the pink of the artist. The negative taken through the blue filter gives the minus-blue positive, which is approximately the yellow of the artist, and the complementary of the blue of the taking filter.

These three colour components are superposed in exact register, and can be mounted either on paper or as a lantern slide. It will be seen that where there is white in the picture, there will be an image in each component negative, but no image in any of the component positives, so that the white paper base will be clearly visible; or if the components constitute a lantern slide, the white projecting light will be freely passed. Similarly, where there is black in the picture, there will be no image in any of the component negatives, and there will be a superposition of three colour images in the combined positives, which produce the black. Where there is green in the picture, there will be images in the minus-red (the blue) and the minus-blue (the yellow) positives, and the green is reproduced by the same subtractive processes as described above in connection with a mixture of yellow

and blue pigments. Other colours are similarly reconstituted.

Supposing, then, that we have three coloured living-picture films made from negatives taken through the red, green, and blue filters instead of single images, and that these films are united in register, the projection of such a tripart film would give a Living Picture in colours. Thus we have a second method, theoretically possible, and on which much experimental work is being done, but again involving practical difficulties which so far have not been successfully removed.

Other Additive Methods.—(1) If we project colours alternately in sufficiently rapid succession, the resultant effect will be that the eye will merge the colours by persistence of vision. Thus, if, in taking a film, the successive exposures are made through red, green, and blue filters, each colour filter recurring at every third exposure, then the positive film will contain a recurring series of component red, green, and blue component images. If the film is passed through the projector, and the red, green, and blue filters caused to recur in front of the corresponding components, or alternatively, if the components are coloured or toned red, green, and blue respectively, then, provided the components recur sufficiently quickly for the eye to combine the colours, we should obtain not only the effect of motion, but also of colours. Kinemacolour is a development of this process.

(2) If a surface is ruled with a series of lines alternately red, green, and blue, leaving no spaces, and so fine that the eye cannot detect any of the lines singly, the combined effect of the colours is produced. The same effect is produced if, instead of lines, we have small areas forming a mosaic. The use of such a screen for colour photography was introduced by Du Hauron in 1892. If a screen of this kind is coated with a sensitive emulsion, and the exposure made through the screen, the different

sets of red, green, and blue areas serve the same function as Clerk-Maxwell's colour filters. If the exposed plate is developed as a positive, then the red, green, and blue component images will be split up into small areas behind the corresponding colour areas. As the eye cannot perceive the individual colour areas, it sees the combined effect of the three-colour images and a colour picture results. This is the principle used in producing what are known as Autochromes, Lumière's screen which is used having colour areas made from very small starch grains. If, then, we could form a screen on celluloid and make a living-picture film in this way, we should presumably

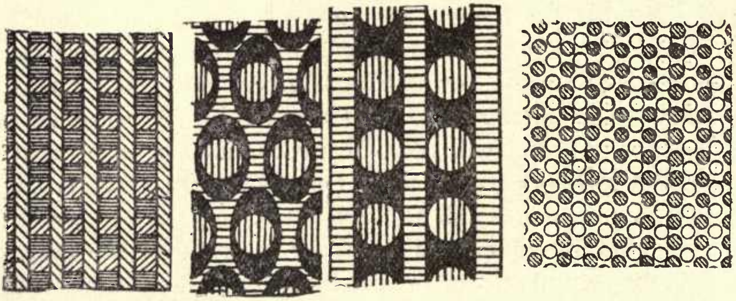


FIG. 239.

obtain a Living Picture in colours. Unfortunately, there are many material difficulties in the way of obtaining for Living Pictures the very beautiful results obtained in still-life subjects. Joly, in 1896, introduced a modified method in which the screen need not be inseparably associated with the sensitive plate. He used the line screen first described, and in exposing the negative the screen is pressed into close contact with the sensitive surface.

On printing a positive transparency we obtain images of the three colours, corresponding to Clerk-Maxwell's images, but broken up, and each image is associated with the corresponding colour filter by recombining the screen

with the positive, so that the red, green, and blue lines register with the images taken through them. The line screens have been improved upon, and various screens suggested, in which the colours are grouped according to a definite regular pattern, some of the patterns used being shown on a magnified scale in Fig. 239, in which the differently shaded or clear areas represent the different areas coloured in primary colours. The advantage of having a separate screen is that any number of positives can be produced from the one negative, whereas with a screen in which the colour areas are quite promiscuous and without any arrangement and order, no two screens will be alike, and the re-registration of the screen with the positive would be an impossibility. The direct application of this method for Living Pictures has been suggested, and much experimental work is being done on this process.

Sensitiveness of Photographic Plates to Colours.—In all the above methods it has been assumed that the sensitive plates used are equally sensitive to all colours. An ordinary plate, however, is not so sensitive. If exposed to the spectrum, the density of the image will vary considerably, the most active colours being at the blue end of the spectrum, and the least active at the red end. It is possible, however, by suitably treating the plates with selected dyes and chemicals to make a plate sensitive to green or red. A plate thus treated is known as an orthochromatic plate. By treating the plate with a selected combination of dyes, it is possible to make it more equally sensitive to both green and red. Such a plate which is sensitive to all colours is known as a panchromatic plate. One of the greatest difficulties in obtaining Living Pictures has been to find a panchromatic emulsion which is sufficiently red-sensitive. This difficulty is not so acute for still-life photography, since the restrictions in the time for exposure are not so great as with Living Pictures, where sixteen or more exposures every second are necessary.

The foregoing brief review of principles will, it is hoped, enable the reader to more easily follow the methods used for obtaining Living Pictures in colours.

Friese Greene's Method.—The first recorded method, by Friese Greene in 1899, is somewhat unique, and for that reason alone is interesting. It is primarily a method for still-life photography. A disc (Fig. 240), containing three red, green, and blue sectors, is rotated rapidly in front of the camera lens, so that the filters recur in rapid succession. A positive is made from the negative, and is projected behind the rotating disc. The patent specification explains that the negative will contain the vibrations, not only of the three colours employed, but also of all the

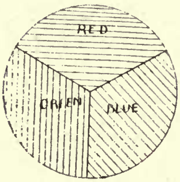


FIG. 240.

varieties of colour caused by the blending of these colours, and that the projected picture will show all the colours of the original. The idea apparently is to assist the plate to record and reproduce the colours projected on the plate. Unfortunately, the plate does not respond, and the method fails when put to practical test.

Persistence of Vision Methods: Kinemacolour.—The next proposal appeared in 1899 by Lee and Turner, and formed the starting-point of the modern Kinemacolour process. It is partly a persistence of vision method and partly a triple projection method. A three-sectored disc, as used by Friese Greene, is rotated in front of the camera lens at such a speed that the successive exposures on the film are made through the successive sectors. We thus obtain a

recurring series of red, green, and blue colour records. The method of projecting is somewhat involved. Three

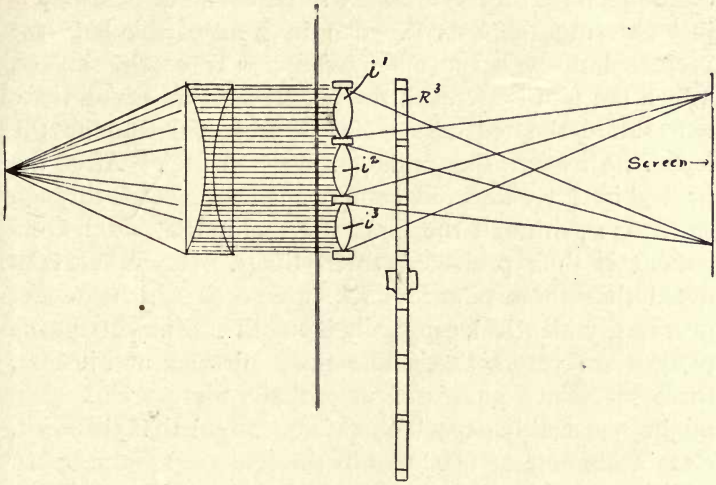


FIG. 241.

consecutive pictures are superposed at a time by means of three projecting lenses, i^1, i^2, i^3 (Fig. 241), the red picture through a red filter, the green picture through a

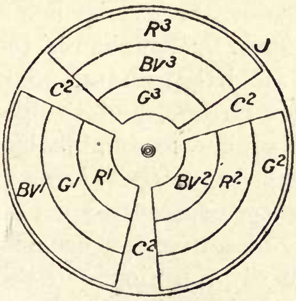


FIG. 242.

green filter, and the blue picture through a blue filter. This is accomplished by a shutter (Fig. 242) formed of sectors, each sector having three concentric coloured

bands. The colours are stepped as shown, and the three sectors are separated by black sectors. If we follow one of the pictures on the film, say a red component, which is just entering the lens i^1, when in front of this lens it is projected through the outer red sector R^3 on the shutter. When the film is stepped, the black sector masks all three lenses, and the red component is projected through the lens i^2, through the middle red sector R^2. After the next shift the same red component is projected through the lens i^3, through the inner red sector R^1. Each component is thus projected three times. It will also be noted that three pictures are superposed which are not necessarily identical, especially if the living subjects in the picture are very active. The three pictures are, in fact, three successive phases of an ordinary picture film. We might reasonably expect, therefore, to find that there is a certain amount of fuzziness in the projected picture. In addition to this difficulty, the knowledge with regard to emulsions and filters was not at this time sufficiently far advanced to obtain a proper balance of colours in the picture. Nevertheless, the method had in it the germs of great possibilities, and many suggestions followed. The direct application of the persistence of colour vision method was suggested by Vaughan in 1902. The negative was to be taken through the same sectored screen (Fig. 240), as used by Friese Greene, and the positive band projected through a similar screen, in which the sectors are separated by black sectors. This method obviates the superposition of three consecutive pictures, but introduces others, since in order that the eye may recombine the colours the speed of projection, and therefore of taking, has to be correspondingly increased. The fact that the exposures have to be made through colour filters makes matters much worse, and the exposure which is necessary is reduced beyond the limits for which the film can be sensitized for red. The strain on the film, moreover, both

in taking and projecting at nearly three times the ordinary speed, is prohibitive.

In 1902 Mr. G. A. Smith was invited by Mr. Urban to assist in a thorough series of experimental researches with a view to obtaining colour reproductions. Mr. Smith's story has been told by himself in a lecture before the Royal Society of Arts on December 9, 1908. The chief problems then existing were to find a film equally sensitive to all colours, and a method which would only necessitate the use of ordinary films and existing machines and accessories. Mr. Smith departs from Maxwell's three-colour system of colours, and maintains that it is possible to exhibit satisfactorily every colour to the eye, including the purest of whites, by dividing the spectrum into two parts. "If," says Mr. Smith, "we ask individuals to set down the principal colours of Nature, placing them in order of luminosity or brightness to the eye, the average of the lists will be as follows: white, yellow, orange, red, green, blue, violet, indigo, black. . . . I find that it is possible with two carefully adjusted filters to pass to the sensitized plate or film colours in proportions parallel to the above order. Through one filter I pass white and yellow, then through orange and scarlet, to the darkest red I can sensitize for. Through the other filter I pass white and yellow again, as these two are at the head in luminosity and require fullest representation; then on through green, blue-green, blue, and violet, in the proportions suggested by the above luminosity list. The aim is to secure, by a careful adaptation of filters to emulsion, a record of colour luminosity stated in gradations of tone from white to black, through a scale of greys, this scale being fully represented in two successive pictures. I take the pictures with an Urban Bioscope camera fitted with the required filters to come into action alternately. One film only is used, of the usual standard size, and I take the pictures at the rate of not less than sixteen per second

through each filter, or thirty-two pictures per second in all. When the negative record has been duly developed, and a positive transparency developed from it, this positive transparency represents, by its gradations of tone from black to white in each successive pair of pictures, not only a record in form and shape, but it also acts as a filter or sifter of light; for when it is passed in the path of rays of coloured light it will screen or filter them so as to reconstruct for our eyes the various proportions of colour luminosity which were present in the scene when the record was made. . . . The question now is, What rays of colour are we to use? Apparently we must use the same colours that we used as filters in the camera, and, in fact, we may do so with pleasing results. But theoretical critics will point out that, owing to the unfortunate over-sensitiveness of the film to violet and blue, we must, of necessity, have cut these colours down to such an extent in our camera that if we use the same filters for reconstructing colour for the human eye, their absence will be sorely missed—our whites will be so deficient in blue and violet that they won't be white at all, but orange or yellow. Our reply to this contention is, that white is very largely a comparative sensation. What we agree to call white in a painting, for instance, is often quite different from what we agree to call white in another painting, if we take steps to compare the two 'whites' with one another. One may be yellowish or greyish compared with the other, yet both are white enough in their proper place in the picture, when surrounded with colours in proper 'key,' as it were, to them. Again, the whitest of paper will look yellow when compared with the purest white of fresh fallen snow. Therefore, our whites produced by the mixture of coloured lights may possibly be somewhat yellow as a matter of spectroscopic reality; but if the human eye accepts them as white by the comparison with other colours in the same picture, we need scarcely

bother our heads further. But another way of meeting the critical objection that the analytical filters of our camera are necessarily too deficient in violet and blue to give a proper rendering of colour when used as synthetical or reproduction filters in projection, is to introduce the missing beams of violet and blue into our projecting instrument, and so make ourselves practically secure of the whites or 'all-colour light,' required on theoretical grounds. This I find it an advantage to do; and if you examine the light emanating from the projecting machine when lighted up and at work, you will see that beams of red and green are alternately issuing from the lens, and that these beams have added to them by means of a supplementary shutter just those proportions of violet and blue required to make pure white when all are mixed. Thus we have light on our screen for our whitest objects, which contains, as it should contain to conform to theory, every colour of the spectrum from dark red to violet."

In the camera used for taking Kinemacolour negatives the lens L (Fig. 243A) is exposed alternately behind the red and green coloured segments R and G, the opaque shutter S masking the lens during each shift of the film. The shutter used in the projector comprises the orange-red and blue-green sectors R′, G′, between which are transparent sectors T, which cross the lens during the shift of the film. At this period a separate violet shutter crosses the lens to give the violet component, as referred to above. The centre part of the blue-green section of the shutter is modified in density to obtain a necessary balance of colour. The pictures taken through the red and green filters in the camera must, of course, be projected through the corresponding segments of the shutter in the projector. Fig. 244 illustrates a view of the projector.

It is well to have the theory of the process from the inventor himself. The whole subject of colour and colour

phenomena is, after all, very far from being understood, and it and the theories and problems arising from the inventor's description open a very wide field for discussion. According to the generally accepted theories, a two-colour system in which only two-colour component images are obtained, can at best be but a compromise for obviating some of the difficulties involved in a three-colour system. According to Dr. Mees, the process is "a striking testimony

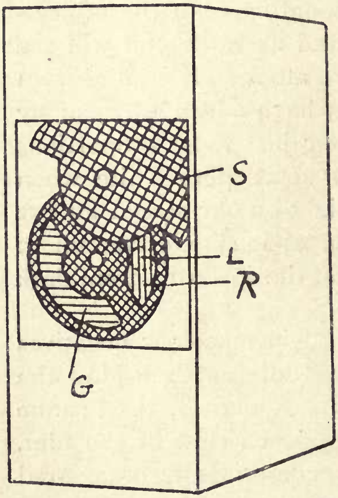


FIG. 243A.

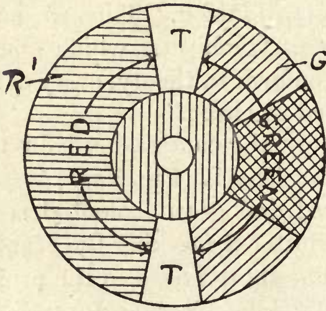


FIG. 243B.

to the good practical results which may sometimes be obtained from a theoretically inaccurate system."*

Theory or no theory, however, the facts remain that it was the first commercial process for obtaining Living Pictures in colours, that the colour illusion is in the majority of cases strikingly good, and that the enjoyment of hundreds of thousands has made the name of Kinemacolour deservedly famous.

* *Nature*, October 26, 1911, p. 556.

Various suggestions have been made from time to time by way of modifications and improvements, chiefly with

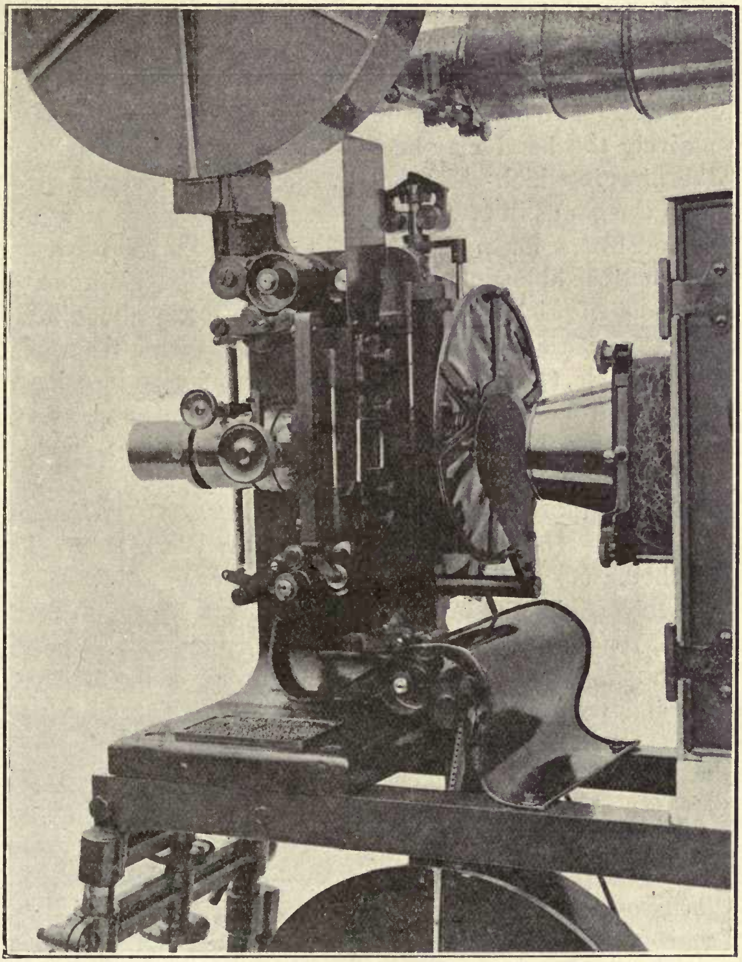


FIG. 244.

regard to details. The selection of colours offers a wide scope for research. It has been proposed to interspace

the pictures with black-and-white projections at intervals, presumably to rest the eye and to enhance the colours. The eye cannot, of course, detect the interposed pictures. Again, it has been proposed to dispense with the rotating coloured filters, and to use a coloured band having alternate red and green colour patches which will coincide with the pictures. The band may be attached to the film, or alternatively the band may be loose and perforated just like the film, in which case the sprockets are relied upon to keep the bands in proper register. An alternative to using colour filters for projection is to print the pictures as coloured components, for which purpose the bichromate methods of printing are recommended. Various modifications have been suggested for the Kinemacolour shutter; for example, to graduate the colour sectors used in colour, starting from red to yellow for one sector, and green to violet for the other sector. Other suggestions include means for adjusting the relative areas of the sectors.

Simultaneous Projection Methods: Gaumont's "Chronochrome." — The direct application of Clerk-Maxwell's method, as above suggested, has obvious difficulties. Three cameras and projectors would be necessary to start with, rendering the cost prohibitive. Very few, indeed, of the methods for still-life photography could for this, among other reasons, be possible for Living-Picture work. One of the earliest methods suggested for Living Pictures was suggested by Davidson in 1904. Colour filters, *i*, *j*, *k*, are fitted to the camera, as shown in Fig. 245, and by means of mirrors, *e*, *f*, *g*, *h*, three images are obtained on the focal plane at *abc*. The system may be modified for two-colour work by rearranging the filters and mirrors. It is not necessary, however, to use reflectors to obtain the component images. Friese Greene suggested in 1905 the use of prisms. A small angled prism, *d* (Fig. 246), is fitted just behind the lens *c* of the camera, and operates to produce a refracted image, *nq*, adjacent to the direct

image, *rj*. These images are taken and projected through two-colour filters, *e*, *f*, and the film is moving through the plane *rn*. This method was exhibited in 1906, and the results inspired the hope that the method would be of practical value. None of such methods as the above in which mirrors or prisms are used to obtain the component images have, however, emerged from the lecture-room or the laboratory.

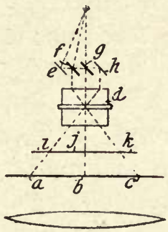


FIG. 245.

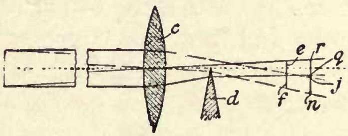


FIG. 246.

Multiple Lens Systems.—One solution of the difficulties of the above systems lies in the use of a separate lens in taking and projecting each component film. A practical difficulty in such method is to focus pictures of equal size sufficiently close together on the film, and to recombine them in register on the screen. Also the separate pictures are taken from adjacent positions, and this renders still

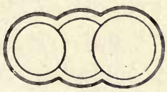


FIG. 247.

more difficult their exact superposition on the screen. The arrangement of objectives suggested by Christensen is illustrated in Fig. 247. To get the axes of the lenses as close as possible, and to equalize the exposures for the different colours, the lens for the blue colour is in the centre, and is recessed into the other two for the red and

green, which themselves are so proportioned as to equalize the exposures necessary for the three colours. In order to obtain pictures of exactly equal size, the lenses have the same focal length for the colours they respectively pass.

Arrangement of the Different Colour Component Pictures on the Film.—The simplest arrangements are those in which the component pictures are one above the other on an ordinary film, or side by side either on separate films of ordinary size, or on a film of twice or three times the ordinary width. In the first case the feed mechanism must feed the film through the space of two or three pictures at each shift, which would be a great strain on the film and feed mechanism of the camera or projector. In the latter alternatives the wide film might not keep perfectly flat, and special apparatus for the wide film is necessary. If the component pictures are squeezed into the space of an ordinary picture, as suggested by Ulysse, in Specification No. 17,872 of 1910, the pictures will be excessively small, and in addition there is the optical difficulty of obtaining good pictures so close together on the film.

Gaumont's "Chronochrome" System.—To M. Gaumont, of Paris, belongs the credit of being the first to successfully overcome the many difficulties and to successfully realize a practical three-colour system for Living Pictures in colours. The system, moreover, needs no scientific apology, as it is based on Clerk-Maxwell's original three-colour process, which is universally recognized as giving the best rendering of colours. The demonstrations in Paris in December, 1912, and in London in March, 1913, met with well-deserved appreciation from all quarters, and was universally recognized as being conclusive evidence of a notable achievement. The pictures are taken in sets of three, one above the other, on a film of standard width. This avoids any gauge complications. The pictures are not, however, of normal size, but each set of three pictures occupies the space of about two ordinary pictures. This

necessitates a feed through two ordinary picture spaces at each shift. To get good pictures so close together on the film three lenses are used, each of which is cut off by two parallel planes. The lenses are thus similar in size and shape. Each lens is fitted with its colour filter. The optical superposition on the screen is accomplished by a very ingenious arrangement of the projecting lenses A, B, C (Fig. 248). The outer lenses A, C, are not only

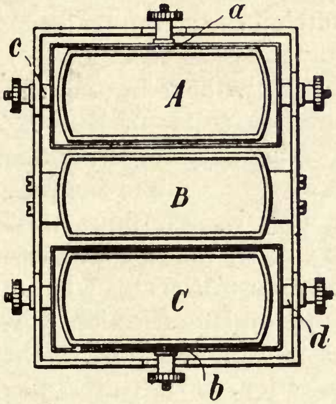


FIG. 248.

adjustable towards and away from the centre lens B, but are also pivotally adjustable both about their horizontal axes, *c*, *d*, and their vertical axes, *a*, *b*. The three lenses carry the colour filters, and are used in conjunction with three auxiliary condensers, situated behind the film gate. There is no room for two opinions as to the excellence of the pictures produced and exhibited, and that the process should have a future before it.

CHAPTER VIII

LIVING AND SPEAKING PICTURES

To make a picture on the screen realistic something more is necessary than the visual effect alone. To see persons in the act of talking without hearing what is said, or to see waves dashing on rocks, or lions seemingly roaring away, without hearing anything other than the faint buzz of the projector, leaves an impression of something lacking. From the very earliest times this want has been felt, and it is now rarely that a Cinematograph exhibition is given without a musical accompaniment of some sort. A suitable and appropriate selection of pianoforte music greatly improves an exhibition, and, on the other hand, an inappropriate selection, or a bad rendering of a good selection, is worse than no music at all. An ordinary piano is all that is used in many places, but a piano, organ, orchestra, or orchestra substitute, such as the Cinephonium, however excellent the instrument may be, have limitations; and while these can be adopted to give music harmonizing to a large extent with most pictures, there are many sounds and noises, musical and otherwise, which require special devices for imitation, such, for example, as traffic, the buzz of aeroplanes, pistol shots, waves, and many others. Invention and ingenuity have not failed to supply means for imitating these in a very realistic manner, but it requires a very considerable amount of skill and practice to utilize such means to the best advantage. The person in charge of the music and effects has a very important part to play in any

picture exhibition. The effects can easily be underdone, or overdone, or badly done; they can too easily be brought in at the wrong time, and the person in charge requires to know the films beforehand, in order to be able to manipulate his tools in the right way and at the right time.

The reproduction of the actual sounds, as well as the picture, was attempted in the earliest days of the Cinematograph, and was used by Demeny for his Photophone, and by Edison for his Phonokinetograph and Kinetophone. The production of imitation sounds or effects is quite a different problem to the reproduction of the actual sounds themselves. In the latter case the sound record has to be made and reproduced with the picture. It must, moreover, keep in time with the picture; that is to say, there must be "synchronism" between the sound and the picture records. The ordinary gramophone record is obtained by the action of a vibrating membrane which produces a series of indentations in a soft surface of wax. These indentations are used to reproduce the vibrations of a membrane, and thereby reproduce the original sounds. Stripped of all refinements, this is the essential principle of the gramophone. If, then, a record of the sounds can be made simultaneously with the photographic record, it would not at first sight appear to be difficult to reproduce them in synchronism. The first of these problems is rendered difficult by reason of the limitations of the sensitiveness of the recording gramophone. The recording instrument must be within a certain range of the sounds, and for a speaker or actor the range is not a large one, and it is difficult to get the instrument near enough and keep it outside the picture view. Accordingly another method has been resorted to, which is applicable in a large number of cases. The gramophone record is taken first, and the picture film is produced to the accompaniment of the record. To succeed with this method it is obviously essential that

the speaking, singing, or acting, should synchronize with the sound record for synchronism between the same return and the picture film to be possible. A further limitation arises from the size of record obtainable. A small or short record means a short film. The size and length of an ordinary record is very limited, and for a speech, sketch, or piece of any material length, several records are necessary, and these would need to follow on at the proper time. Having obtained the record and picture film, the problem of reproducing them synchronously is still a formidable one. It is, of course, theoretically possible for the operator to keep his eye on the screen and his ear on the gramophone, and to control the projector or gramophone so as to maintain synchronism. This, however, throws an additional responsibility on the already overburdened operator, and is not a practicable method. Accordingly, either an auxiliary device is necessary to automatically indicate to the operator if the synchronism is being maintained, or some means by which the running of the projector or gramophone, or both, is automatically adjusted to maintain synchronism.

Alike with this problem of synchronism, as with the problem of colour cinematography, one almost instinctively looks to see what Messrs. Gaumont have achieved. In one of their earliest methods, introduced in 1902, a motor, AB (Fig. 249), is used to drive the projector K. This motor is electrically controlled from the gramophone, L. The gramophone drives a shaft, N, carrying collector rings, X, of an electric circuit; and carrying also rotating brushes, D, E, which rub on a divided collector, the sections of which are connected to the stator of the motor, AB. The next step in advance is the use of synchronized motors for driving both the gramophone and the projector. Mester, in Germany, appears to have been working on the same lines, and special types of

motors are used. The two motors of identical design and the same power are driven from the same current, and in order to better maintain synchronism the motor armatures each have a number of sections which are connected in pairs. A switchboard near the projector includes a starting switch, whereby the gramophone is first set in motion; and when the record commences, the gramophone disc operates a switch to start the projector. A voltmeter on the switchboard indicates any want of synchronism which is corrected by accelerating or retarding the projector. This is effected by coupling the projector with its driving motor through a differential gearing, which is operated from a separate motor. This latter

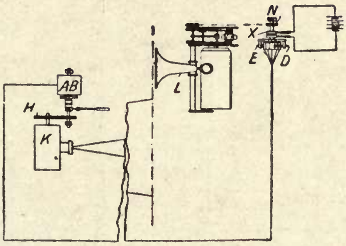


FIG. 249.

motor is started by an auxiliary two-way switch, so that the differential can be used to retard or accelerate the projector to restore the synchronism. The results obtained with the Chronophone are extremely satisfactory, and by the use of the Auxetophone, in which the sound is intensified by means of compressed air, the possibility of the Chronophone in large halls is quite a possibility, as is evidenced by its use at the Hippodrome in Paris, which has a seating capacity of over four thousand.

The use of indicators for automatically indicating to the operator any want of synchronism has been adopted by many inventors in various ways. In one of the earliest (Fig. 250) two indicating elements are used, one

consisting of a disc, *s*, rotated directly from the projector *b*, and the other a concentric pointer, *r*, rotated by an electro-magnet, which is intermittently energized by a circuit, completed on every revolution of the gramophone spindle *d* by means of a cam, *e*, on the spindle. The disc *s* carries a mark, and so long as the mark on the disc and the pointer are coincident, synchronism is being maintained. If the pointer leads or lags, the projector is speeded up or slowed down accordingly to restore synchronism.

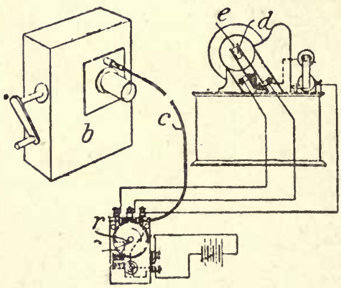


FIG. 250.

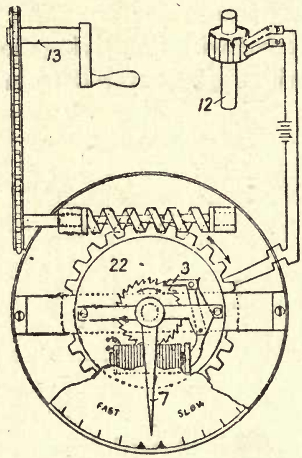


FIG. 251.

There is undoubtedly a comparative simplicity in such a method as this, of which there have been many varieties. In one by Thomassin (Fig. 251) a pointer, 7, is rotated intermittently by a pawl, 3, and an electro-magnet energized from the shaft 12 of the gramophone. The electrical escapement is mounted on a coaxial disc, 22, which is rotated in the opposite direction from the projector shaft 13. So long as synchronism is maintained there will be no movement of the pointer, and any movement of the pointer indicates the adjustment necessary

for the projector. With this apparatus there is a single indicating element only.

Another apparatus of this type, and the only one which appears to have survived and found its way into anything like extensive use, is the Vivaphone, devised by Mr. Hepworth. In this instrument a wheel, B (Fig. 252), carrying the indicating pointer M, is rotated by two pawls, D, I, which are actuated by two electro-magnets, G, L. These electro-magnets are intermittently energized from the projector and gramophone respectively. The spindle B′ of the wheel B rests between parallel bars, A^3, and if synchronism is upset, one pawl will rotate the wheel more

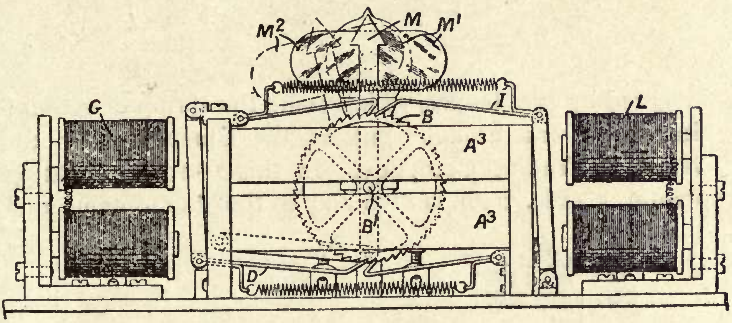


FIG. 252.

quickly than the other one, and thereby cause the pointer M to move to one side or the other. The pointer carries two red and green discs, M^1, M^2, which are thus brought opposite the lamp, and indicate any disturbance of synchronism. The attractiveness of the Vivaphone is that it is adaptable for any gramophone and any projector. The make and break contacts for intermittently energizing the electro-magnets are carried on two fittings, S, T (Figs. 253, 254). The fitting S rests on the disc of the gramophone, and has a knife-edge engaging in the slot of the centre pin, and the fitting T is carried by the driving shaft of the projector respectively. These fittings, S, T,

and a battery, X, are connected up with the lamp K and electro-magnets G, L, of the indicator, as shown in Fig. 255.

Another somewhat different method and apparatus,

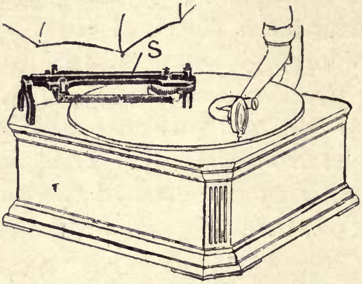


FIG. 253.

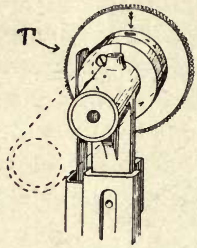


FIG. 254.

invented by Mr. Jeapes, which bears the stamp of extreme simplicity, was brought out as the Cinephone by the Warwick Trading Company. In this method a rotating pointer, 5 (Fig. 256), is attached to the gramophone and

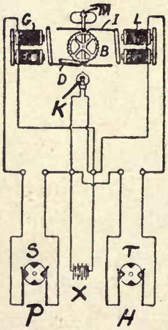


FIG. 255.

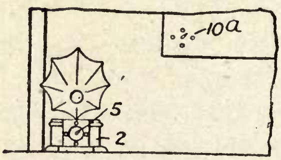


FIG. 256.

driven by it. The gramophone is positioned so that a record of the rotation of the pointer is produced on the film at one corner thereof. The gramophone is placed near the corner 10^a of the projection screen, on which the

reproduction of the pointer appears. The operator then controls the projector so that the reproduction maintains the same angular speed as the pointer.

A difficulty with several synchronizing devices where an indicating pointer is used arises when a film breaks or is damaged, and a section of it has to be cut away. In such cases it is necessary to slow down the projector until the gramophone catches up, but there is no visible indication when synchronism is restored. With the Cinephone, however, the restoration of synchronism is indicated by the reproduction of the pointer on the screen.

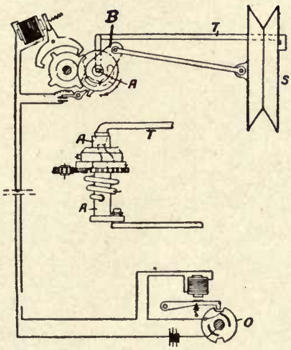


FIG. 257.

The above by no means exhausts the devices of this character, which have been many and various, and a list of which is included in the Patents Appendix.

In another type of device, by Count Proszynski, the projector is coupled with the gramophone by connecting the spindle A (Fig. 257) of the projector with an air-pump bellows, S, the air outlet T of which is regulated from the phonograph O in such a manner that when synchronism is faulty the bellows actuate a brake, B, or otherwise control the speed of the projector.

In another and altogether different system, invented by Mr. Lauste in 1906, the sound as well as the picture are

simultaneously recorded on the film. To obtain a photographic record of sound may not be recognized as a common process, but it is nevertheless quite a possible one, and some method of recording the sound and the picture simultaneously on a picture film, either by photography or in some other way, may be found to be one of the best solutions of the problem of synchronization. It certainly would solve the problem of the long piece or play, since the continuous film is used for the sound record as well as the picture record.

In Lauste's method the sound record is made photo-

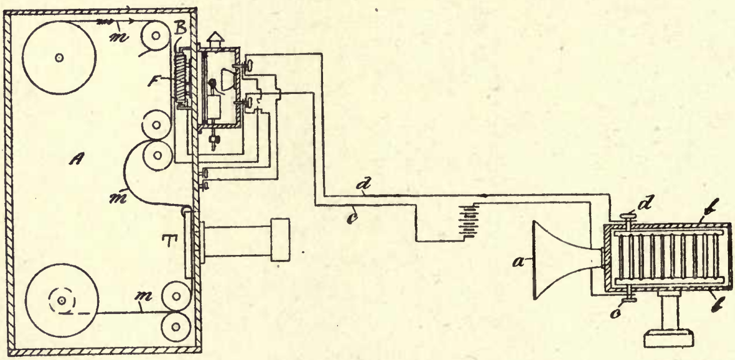


FIG. 258.

graphically. A microphone transmitter, such as is used for collecting the sound-waves at concert halls for transmission, or, alternatively, one or more horns or trumpets, *a* (Fig. 258), connecting with any ordinary loud-sounding telephone or microphone transmitter, *b*, receives the sounds, and transmits them over an electric circuit, *c d*, to the receiver in the camera, A. At the receiver is an electro-magnet, B, and the varying electric currents produced by the action of the sound-waves in the microphone transmitter *b* vibrate a slotted diaphragm, C′ (Fig. 259), which moves between a fixed light and a fixed slotted

diaphragm, C. The vibrations of the diaphragm C′ corresponding to the sound-waves produce variations in the light openings through the diaphragms C, C′, and consequently variations in the intensity of light falling on

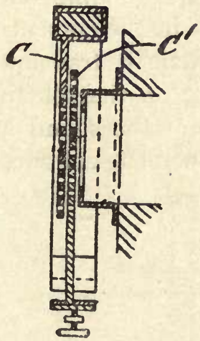


FIG. 259.

the sensitive film *m* behind the diaphragm are produced. The sensitive strip *o* (Fig. 260), on which the light falls, is adjacent to the picture area *o′* of the film *m*, and, when developed, forms the sound record. The sound record must be made while the film is moving continuously,

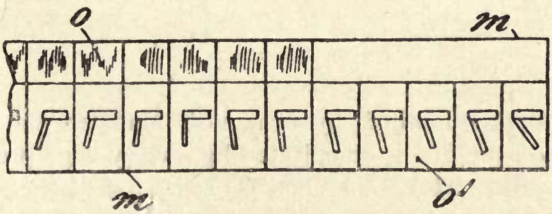


FIG. 260.

before or after it is fed intermittently through the gate T of the camera. It will thus be seen that the sound record on the film is a few picture lengths behind the corresponding section of the picture record. To reproduce the sound record, use is made of the fact that the re-

sistance or conductivity of a selenium cell, when included in an electric circuit, *b*, varies in accordance with the intensity of light acting on it. In the projector (Fig. 261) the film passes between a lamp, *p'*, and a selenium cell, *r*, in circuit with a loud-sounding microphone or telephone, H. The variations in the current produced by the variations in the light intensity transmitted through the sound record *o*, and falling on the selenium cell, cause a corresponding variation of the sound membrane in the loud-sounding microphone or telephone, H.

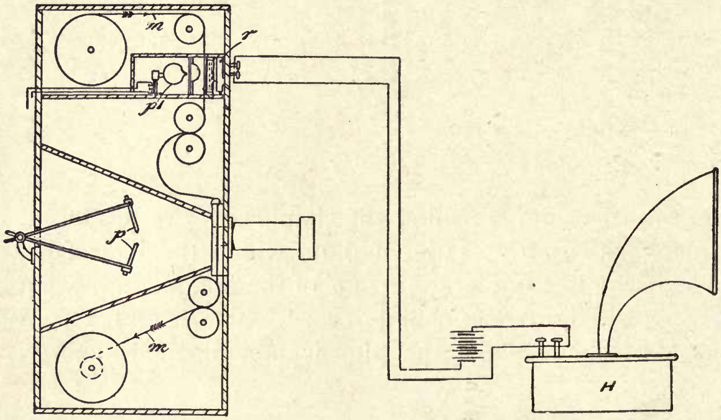


FIG. 261.

In another method, by Mrs. Von Madeler, the sound record on the film is constituted by a wavy edge produced on the film. The sound box B (Fig. 262) of the gramophone has to be actuated in proximity to the film A. The stylus consists of a rotated cutter, C, mounted on a pivoted bracket, D, and vibrated by an arm, E, connected with the diaphragm of the sound box B. The cutter C is adjacent to the edge of the film A, and the sound-waves are thus recorded and represented by the wavy edge of the film produced by the cutter. As in

the previous case, the sound record is taken while the film runs continuously, either before or after the film is fed intermittently through the gate. A duplicate record may be simultaneously reproduced on the other edge of the film. To reproduce the sound record the sapphire or needle F^1 (Fig. 263) of the gramophone sound box has a flat end resting against the edge of the film A as it passes through the projector. The pressure of the needle is regulated by the balance weight $G.^2$ An alternative to the method of cutting the edge of the film by a rotary cutter consists in heating a platinum wire to a dull red heat sufficient to burn

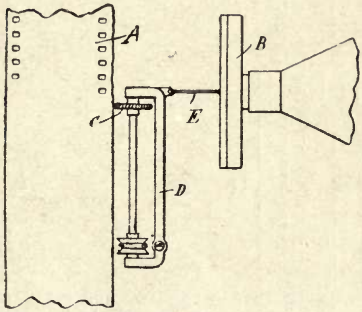


FIG. 262.

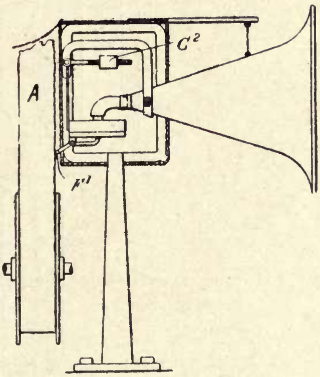


FIG. 263.

the edge of the film, and mounting this wire on an arm or frame connected with the diaphragm of the sound box, so that the vibrations of the wire may burn to a variable depth along the edges of the film. This method may be used to produce a film sound record of an ordinary disc record. With the above method the gramophone must obviously be near the camera and the projector, whereas by the photographic or photo-electric method the gramophone can be anywhere both in recording and reproducing. It is also possible to use more than one gramophone, which is Rosenberg's method, devised more especially to com-

pensate for the disturbing effect on the sound production due to the movement of the source of sound—say a speaker or actor. This dependency of the sound received, upon

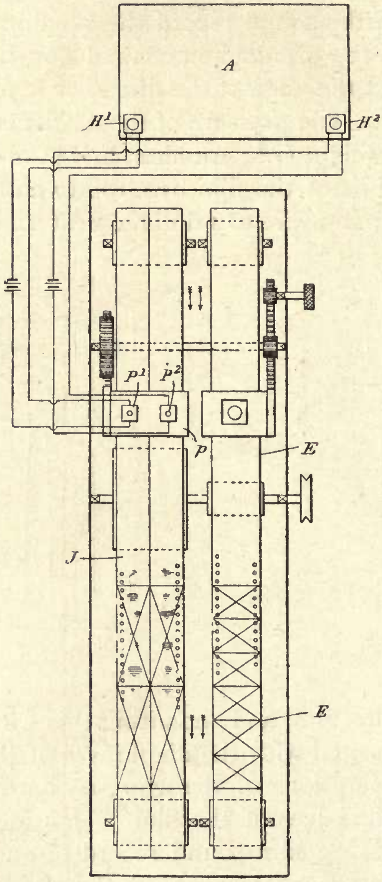


FIG. 264.

the movement and distance of the sound, is well instanced by the sound of a whistle of an approaching and passing train. To produce a more correct sound reproduction two microphones, H^1, H^2 (Fig. 264), are used to produce

a sound record, J, on a film running at one side of the picture film E. For reproduction, two sound-reproducing devices, H^1, H^2, are put on either side of the screen, A. The films, both in the camera and projector, can be run from the same gearing, and the synchronism can be adjusted by having a movable gate, *p*, carrying the sound-reproducing devices P^1, P^2. A further advantage of having a reproducer on either side of the stage is that the sound appears to come from the correct side of the picture.

The methods above described do not by any means exhaust the many alternatives which might, if space permitted, be described. For example, Mr. Von Madeler has recently been engaged in perfecting the method of

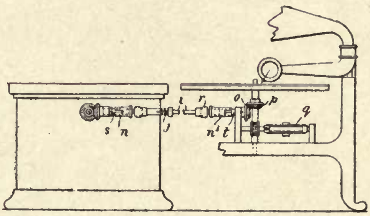


FIG. 265.

directly coupling the projector and gramophone by intermediate shafting, which may be either rigid or flexible. In Fig. 265, which illustrates one method, the gramophone is driven from the picture machine through the shaft *i* and bevel gears *o*, *p*. The speed of the gramophone is limited by a governor, *q*, which has means for setting it as desired. The shaft *i* is telescopic at *j*, and has a ball and socket joint, *r*, to allow for lateral and vertical movement; the bayonet caps *n*, *n*, at either end to link the shaft *i* with the driving shaft *s* of the projector and the gramophone shaft *t*.

In concluding the subject of synchronization it is not superfluous to raise the not unimportant question, How far is the use of the gramophone really desirable or useful?

Although it is now being more extensively used, it has so far been comparatively little used, and the reason is not far to seek. The peculiar tone of even the most perfected gramophone leaves much to be desired, and until this can be removed, and the gramophone is so perfected as to be a really "musical instrument," its use will probably remain very limited and restricted.

CHAPTER IX

CINEMATOGRAPH ACT AND REGULATIONS

CINEMATOGRAPH ACT, 1909

[9 EDW. VII. CH. 30.]

ARRANGEMENT OF SECTIONS

CHAPTER 30.

AN Act to make better provision for securing safety at Cinematograph and other Exhibitions.

[25th November, 1909.]

Be it enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

Provision against cinematograph exhibition except in licensed premises.

1. An exhibition of pictures or other optical effects by means of a cinematograph, or other similar apparatus, for the purposes of which inflammable films are used, shall not be given unless the regulations made by the Secretary of State for securing safety are complied with, or, save as otherwise expressly provided by this Act, elsewhere than in premises licensed for the purpose in accordance with the provisions of this Act.

The Act was passed on account of the extreme inflammability of the films used, and only applies where inflammable films are used. There is, however, no definition in the Act of the meaning to be attached to the word "inflammable." The Home Secretary has power to make regulations "for securing safety," but has no power to determine the scope of the Act by defining what is meant by the word "inflammable." The definitions given in Murray's Dictionary are—"capable of being inflamed or set on fire; susceptible of combustion; easily set on fire." All films, if subjected to a sufficiently high temperature, are capable of being set on fire, and are susceptible of combustion; but the ease with which they are set on fire, and the susceptibility to combustion, vary considerably. Most of the "non-flam" films now procurable are not easily set on fire, and for practical purposes are absolutely safe. Perhaps the chief danger in the use of celluloid films is the danger of catching fire in the gate if the film breaks below the gate, and the safety shutter does not intercept the light sufficiently quickly. It has been held, however, that it is not a sufficient defence to a prosecution under the Act to demonstrate that the film will not catch fire in the gate if it is inflammable outside the gate (Victoria Pier [Folkestone] Syndicate, Ltd. *v.* Reeve, 76, J.P. 37).* The onus of proof is on the prosecution, who must show that a film is inflammable, and the question as to whether a film is inflammable within the meaning of the Act so as to bring an exhibition at which such films are used within the Act is a question to be decided by the Court in any particular case in which the question is raised. The uncertainty of the present position is, of course, very unsatisfactory, and it has been suggested that one solution of the difficulty would be for the Home Secretary to be given power to subject any make of film submitted to him to a definite test, and if the film satisfied the test, to certify such film as not being inflammable within the meaning of the Act.

* In this chapter J.P. = Justice of the Peace; T.L.R. = *Times* Law Reports.

The Act does not apply to an exhibition given in a private dwelling-house to which the public are not admitted, whether on payment or otherwise (Sec. 7 [4]), nor does it apply to a case where film manufacturers or dealers, *bonâ fide*, in the exercise of their trade of selling or renting out films, project films on to a screen in the presence of customers (Attorney General *v.* Vitagraph Company, Ltd. [*Weekly Notes*, November 28, 1914]). Special provisions are also made for premises occasionally used for entertainments (Sec. 7 [2]), and for structures of a movable character (Sec. 7 [3]). With these exceptions, an exhibition where inflammable films are used cannot be given "unless the regulations made by the Secretary of State for securing safety are complied with, or elsewhere than in premises licensed for the purpose in accordance with the provisions of this Act." The effect of the words is that "an exhibition cannot be given unless the regulations for securing safety, *prima facie* supposed to be made by the Secretary of State, have been complied with, and in addition the performances are to be given in a building licensed under the Act" (per Lord Alverstone, C.J., L.C.C. *v.* Bermondsey Bioscope Company, Ltd., 75, J.P. 53). In Scotland and Ireland the regulations for securing safety are to be issued by the Secretary for Scotland and the Lord Lieutenant respectively (Secs. 8 [1], 9 [1]).

Music Licences.—Where music is provided at a cinematograph exhibition the first question to present itself is whether the place at which the exhibition is held becomes a "place used for music" within the meaning of the different enactments requiring such a place to be licensed.

The general rule is that, where the music is incidental to, and not a principal part of, the entertainment, no licence is required. Now, what is incidental to, and not a principal part of, an entertainment, is a question to be decided from the facts in each particular case; and it may very well be that the same facts which satisfy one tribunal that the music is incidental to the exhibition of pictures will lead another tribunal to the opposite conclusion. The existence of this uncertainty points to the desirability of cinematograph exhibitors obtaining a licence where music is a feature of more than trifling importance. (See L.C.C. *v.* Bermondsey Bioscope Company, Ltd., 73 J.P., p. 458.)

The law requiring a "place used for music" to be licensed is contained not in one Act of Parliament having general application throughout the kingdom, but in different Acts, each having only local application. It is, therefore, incumbent upon a cinematograph exhibitor desiring to have a musical accompaniment to his exhibition to ascertain the provisions of the Acts of Parliament applying to the locality in which he is exhibiting.

In this work it is not possible to do more than briefly outline the principal Acts relating to licences for music. In the cities of London and Westminster, and within twenty miles thereof, licences for music are granted under 25 George II., c. 36, and a place so licensed must have affixed upon the door or entrance in a conspicuous place an inscription in large capital letters, "Licensed pursuant to the Act of Parliament of the twenty-fifth George the Second." These licences, in respect of which no fees are payable, are granted by the London County Council in accordance with the orders made by the Council as the licensing authority under the Local Government Act, 1888.

In the administrative county of Middlesex music licences are granted by the Middlesex County Council by virtue of, and subject to, the provisions of the Music and Dancing (Middlesex) Act, 1894.

Elsewhere in the United Kingdom (except Scotland) music licences are granted by the authority duly empowered by the local Act, or, where there is no local Act, or Part IV. of the Public Health Acts Amendment Act, 1890, has been adopted, by the licensing justices under the provisions of Section 51 of that Act.

Where a place is licensed under either the Music and Dancing (Middlesex) Act or the Public Health Acts Amendment Act, there must be affixed and kept up in some conspicuous place on the door or entrance an inscription in large capital letters in the words following: "Licensed in pursuance of Act of Parliament for Music."

In Scotland a licence for music may be required either under a local Act or under Section 395 of the Burgh Police (Scotland) Act, 1892.

Where it is desired to apply for a music licence, and uncertainty exists as to the proper licensing authority, the best course to adopt would be for the intending applicant to communicate with the clerk to the justices of the district in which the cinematograph exhibition sought to be licensed for music is situate. He will be in a position to give information as to the Act of Parliament under which application has to be made in the district, and as to the giving of notices of the application and the observance of any other preliminary formalities required by local regulations.

Provisions as to licences.

2.—(1) A county council may grant licences to such persons as they think fit to use the premises specified in the licence for the purposes aforesaid on such terms and conditions and under such restrictions as, subject to regulations of the Secretary of State, the council may by the respective licences determine.

The county council may delegate its licensing powers in accordance with Section 5 of the Act, and where the licence is sought within a borough council area, the borough council is the licensing authority, and has similar powers of delegation (Sec. 6). In Scotland and Ireland the provisions as to delegation do not apply (Secs. 8 [4] and 9 [2]).

The Act makes no provision for an appeal from the decision of the licensing authority where an application has been heard and determined on its merits. There is no appeal by means of a case stated (Huish *v.* Liverpool Justices, 30, T.L.R. 25). Where, however, it is alleged that there has not been a proper hearing, or that the decision of the authority is based on improper grounds, a rehearing may be obtained on an application being made to the King's Bench Division for a mandamus to hear and determine.

A limited company is a "person" within the meaning of the Act, but if the licensing authority do not think that a company is a proper licensee, they may, of course, refuse to grant a licence. The general practice is to grant licences to an individual rather than to a body corporate.

Provisional licences have been granted in respect of buildings prior to completion.

The licensing authority may impose conditions in addition to the regulations issued by the Secretary of State, but cannot alter or vary the latter. Such conditions need not be solely directed to the object of securing safety, and the powers of the licensing authority under this section appear to be very wide. The condition requiring the premises to be closed on Sundays, Good Friday, and Christmas Day has been held to be a reasonable condition (L.C.C. *v.* Bermondsey Bioscope Company, Ltd., 75, J.P. 63). Conditions regarding the admission of children have also been made.

(2) A licence shall be in force for one year, or for such shorter period as the council on the grant of the licence may determine, unless the licence has been previously revoked as hereinafter provided.

(3) A county council may transfer any licence granted by them to such other person as they think fit.

(4) An applicant for a licence or transfer of a licence shall give not less than seven days' notice in writing to the county council and to the chief officer of police of the police area in which the premises are situated of his intention to apply for a licence or transfer :

Provided that it shall not be necessary to give any notice where the application is for the renewal of an existing licence held by the applicant for the same premises.

(5) There shall be paid in respect of the grant, renewal, or transfer of a licence such fees as the county council may fix, not exceeding in the case of a grant or renewal for one year one pound, or in the case of a grant or renewal for any less period five shillings for every month for which it is granted or renewed, so, however, that the aggregate of the fees payable in any year shall not exceed one pound, or, in the case of transfer, five shillings.

(6) For the purposes of this Act, the expressions "police area" and "chief officer of police," as respects the city of London, mean the city and the Commissioner of City Police, and elsewhere have the same meanings as in the Police Act, 1890.

53 & 54 Vict., c. 45.

By the Police Act, 1890, Sec. 33, the expression "police area" means one of the areas set forth in the first column, and the expression "chief officer of police" means the officer set forth in the second column hereunder.

Police Area.	*Chief Officer of Police.*
The Metropolitan Police District.	The Commissioner of Police.
A county.	The Chief Constable.
A borough.	The Chief or Head Constable.
A town not being a borough, and maintaining a separate police force under any local Act of Parliament.	The Head Constable or other officer having the chief command of the police.
The River Tyne within the limit of the Acts relating to the Tyne Improvements Commissioners.	The Superintendent or other officer having the chief command of the police.

The term "county" in the above means an administrative county within the meaning of the Local Government Act, 1888, but does not include a county borough. Such parts of any county as are within the Metropolitan Police District, or as form part of any other police area, are not deemed to form part of the county police area.

3. If the owner of a cinematograph or other apparatus uses the apparatus, or allows it to be used, or if the occupier of any premises allows those premises to be used, in contravention of the provisions of this Act or the regulations made thereunder, or of the conditions or restrictions upon or subject to which any licence relating to the premises has been granted under this Act, he shall be liable, on summary conviction, to a fine not exceeding twenty pounds, and in the case of a continuing offence to a further penalty of five pounds for each day during which the offence continues, and the licence (if any) shall be liable to be revoked by the county council.

Penalties.

Proceedings under the Act are summary, and since the Act contains no provisions for an appeal, the general rules as to appeals from a conviction by a court of summary jurisdiction apply, with the result that so far as proceedings under this Act are concerned, there is no appeal except in the two following classes of cases: (1) Where a conviction is before a Metropolitan Police Magistrate, there is, by virtue of the Metropolitan Police Courts Act, 1839 (2 and 3 Vict., c. 71), Sect. 50, a right of appeal to Quarter Sessions in those cases in which the penalty ordered to be paid exceeds the sum of £3 (exclusive of costs). In those cases where the fine does not exceed that sum an appeal can only be secured if the magistrate on application consents to increase the amount. This secures a rehearing of the whole case at Quarter Sessions, and both fact and law are again in issue. (2) Where any person aggrieved desires to question a conviction or order on the ground that it is erroneous on a point of law, or is in excess of jurisdiction, he may apply to such Court to state a special case for determination by the King's Bench Division of the High Court, setting forth the facts and the grounds upon which the proceedings are questioned; and if the Court declines to state a case, the applicant may apply to the High Court for an order requiring the case to be stated.

4. A constable or any officer appointed for the purpose by a county council may at all reasonable times enter any premises, whether licensed or not, in which he has reason to believe that such an exhibition as aforesaid is being or is about to be given, with a view

Power of entry.

to seeing whether the provisions of this Act, or any regulations made thereunder, and the conditions of any licence granted under this Act, have been complied with, and, if any person prevents or obstructs the entry of a constable or any officer appointed as aforesaid, he shall be liable, on summary conviction, to a penalty not exceeding twenty pounds.

5. Without prejudice to any other powers of delegation, whether to committees of the council or to district councils, a county council may, with or without any restrictions or conditions as they may think fit, delegate to justices sitting in petty sessions any of the powers conferred on the council by this Act.

Power of county councils to delegate.

6. The provisions of this Act shall apply in the case of a county borough as if the borough council were a county council, and the expenses of the borough council shall be defrayed out of the borough fund or borough rate.

Application to county boroughs.

7.—(1) Where the premises are premises licensed by the Lord Chamberlain the powers of the county council under this Act shall, as respects these premises, be exercisable by the Lord Chamberlain instead of by the county council.

Application of Act to special premises.

(2) Where the premises in which it is proposed to give such an exhibition as aforesaid are premises used occasionally and exceptionally only, and not on more than six days in any one calendar year, for the purposes of such an exhibition, it shall not be necessary to obtain a licence for those premises under this Act if the occupier thereof has given to the county council and to the chief officer of police of the police area, not less than seven days before the exhibition, notice in writing of his intention so to use

the premises, and complies with the regulations made by the Secretary of State under this Act, and, subject to such regulations, with any conditions imposed by the county council, and notified to the occupier in writing.

(3) Where it is proposed to give any such exhibition as aforesaid in any building or structure of a moveable character, it shall not be necessary to obtain a licence under this Act from the council of the county in which the exhibition is to be given if the owner of the building or structure—

(*a*) has been granted a licence in respect of that building or structure by the council of the county in which he ordinarily resides, or by any authority to whom that council may have delegated the powers conferred on them by this Act; and

(*b*) has given to the council of the county and to the chief officer of police of the police area in which it is proposed to give the exhibition, not less than two days before the exhibition, notice in writing of his intention to give the exhibition; and

(*c*) complies with the regulations made by the Secretary of State under this Act, and, subject to such regulations, with any conditions imposed by the county council, and notified in writing to the owner.

(4) This Act shall not apply to an exhibition given in a private dwelling-house to which the public are not admitted, whether on payment or otherwise.

Application to Scotland.

8. This Act shall extend to Scotland subject to the following modifications:—

(1) For references to the Secretary of State there shall be substituted references to the Secretary for Scotland:

(2) For the reference to the Police Act, 1890, there shall be substituted a reference to the Police (Scotland) Act, 1890:

53 & 54 Vict., c. 67.

By the Police (Scotland) Act, 1890, the expression "police area means one of the areas set forth in the first column, and the expression "chief officer" means the officer set forth in the second column hereunder.

Police Area.	*Chief Officer of Police.*
A county.	The Chief Constable.
A burgh or police burgh.	The Chief Constable or Superintendent.

(3) The expression "county borough" means a royal, parliamentary, or police burgh; and the expression "borough council" means the magistrates of the burgh; and the expression "borough fund or borough rate" means any rate within the burgh leviable by the town council equally on owners and occupiers:

(4) The provision relating to the delegation of powers shall not apply.

Application to Ireland.

9. This Act shall extend to Ireland subject to the following modifications:—

(1) For references to the Secretary of State there shall be substituted references to the Lord Lieutenant:

(2) The provision of this Act relating to the delegation of powers shall not apply:

(3) Any of the powers conferred on the county council by this Act may be exercised by any officer of the council authorized in writing by the council in that behalf for such period and subject to such restrictions as the council think fit:

(4) In any urban district other than a county borough, and in any town, the provisions of this Act shall apply as if the council of the district and the

commissioners of the town, as the case may be, were a county council:

(5) The expenses incurred in the execution of this Act shall—

(*a*) in the case of the council of any county other than a county borough, be defrayed out of the poor rate and raised over so much of the county as is not included in any urban district or town;

(*b*) in the case of the council of any county borough or other urban district, be defrayed out of any rate or fund applicable to the purposes of the Public Health (Ireland) Acts, 1878 to 1907, as if incurred for those purposes;

(*c*) in the case of the commissioners of any town, be defrayed out of the rate leviable under section sixty of the Towns Improvement (Ireland) Act, 1854: Provided that the limits imposed upon that rate by that section may be exceeded for the purpose of raising the expenses incurred under this Act by not more than one penny in the pound:

17 & 18 Vict., c. 103.

(6) The expression "town" means any town as defined by the Local Government (Ireland) Act, 1898, not being an urban district:

61 & 62 Vict., c. 37.

(7) The expressions "police area" and "chief officer of police" mean, as respects the police district of Dublin Metropolis, that district and the chief commissioner of the police for that district, and elsewhere a police district and the county inspector of the Royal Irish Constabulary.

Short title and commencement.

10. This Act may be cited as the Cinematograph Act, 1909, and shall come into operation on the first day of January nineteen hundred and ten.

STATUTORY RULES AND ORDERS, 1910
No. 189

CINEMATOGRAPH, ENGLAND

REGULATIONS, DATED FEBRUARY 18, 1910, MADE BY THE SECRETARY OF STATE UNDER THE CINEMATOGRAPH ACT, 1909 (9 EDW. VII., c. 30).

In pursuance of the power vested in me by the Cinematograph Act, 1909 (9 Edw. VII., c. 30), I hereby make the following regulations:—

GENERAL.

1. In these regulations the word "building" shall be deemed to include any booth, tent, or similar structure.

2. No building shall be used for cinematograph or other similar exhibitions to which the Act applies, unless it be provided with an adequate number of clearly indicated exits so placed and maintained as readily to afford the audience ample means of safe egress.

The seating in the building shall be so arranged as not to interfere with free access to the exits; and the gangways and the staircases, and the passages leading to the exits shall, during the presence of the public in the building, be kept clear of obstructions.

3. The cinematograph operator and all persons responsible for or employed in, or in connection with, the exhibition shall take all due precautions for the prevention of accidents, and shall abstain from any act whatever which tends to cause fire and is not reasonably necessary for the purpose of the exhibition.

Fire Appliances.

4. Fire appliances adequate for the protection of the building shall be provided, and shall include at least the following, namely, a damp blanket, two buckets of water, and a bucket of dry sand. In a building used habitually for the purpose of cinematograph or other similar exhibitions they shall also include a sufficient number of hand grenades or other portable fire-extinguishers.

The fire appliances shall be so disposed that there shall be sufficient means of dealing with fire readily available for use within the enclosure. Before the commencement of each performance the cinematograph operator shall satisfy himself that the fire appliances intended for use within the enclosure are in working order, and during the performance such appliances shall be in the charge of some person specially nominated for that purpose, who shall see that they are kept constantly available for use.

Enclosures.

Regulations applying in all Cases and to all Classes of Buildings.

5.—(1) (*a*) The cinematograph apparatus shall be placed in an enclosure of substantial construction made of or lined internally with fire-resisting material, and of sufficient dimensions to allow the operator to work freely.

(*b*) The entrance to the enclosure shall be suitably placed, and shall be fitted with a self-closing, close-fitting door constructed of fire-resisting material.

(*c*) The openings through which the necessary pipes and cables pass into the enclosure shall be efficiently bushed.

(*d*) The openings in the front face of the enclosure shall not be larger than is necessary for effective projection, and shall not exceed two for each lantern. Each

such opening shall be fitted with a screen of fire-resisting material, which can be released both inside and outside the enclosure so that it automatically closes with a close-fitting joint.

(*e*) The door of the enclosure and all openings, bushes and joints shall be so constructed and maintained as to prevent, so far as possible, the escape of any smoke into the auditorium. If means of ventilation are provided, they shall not be allowed to communicate direct with the auditorium.

(*f*) If the enclosure is inside the auditorium, either a suitable barrier shall be placed round the enclosure at a distance of not less than 2 feet from it, or other effectual means shall be taken to prevent the public from coming into contact with the enclosure.

(*g*) No unauthorized person shall go into the enclosure or be allowed to be within the barrier.

(*h*) No smoking shall at any time be permitted within the barrier or enclosure.

(*i*) No inflammable article shall unnecessarily be taken into or allowed to remain in the enclosure.

Regulations applying only to Specified Classes of Buildings.

(2) In the case of buildings used habitually for cinematograph or other similar exhibitions, the enclosure shall be placed outside the auditorium; and in the case of permanent buildings used habitually as aforesaid the enclosure shall also be permanent.

Provided, with regard to the foregoing requirements, that, if the licensing authority is of opinion that compliance with either or both of them is impracticable or in the circumstances unnecessary for securing safety, and shall have stated such opinion by express words in the licence, the requirement or requirements so specified shall not apply.

Lanterns, Projectors and Films.

6. Lanterns shall be placed on firm supports constructed of fire-resisting material, and shall be provided with a metal shutter which can be readily inserted between the source of light and the film gate.

The film gate shall be of massive construction, and shall be provided with ample heat-radiating surface. The passage for the film shall be sufficiently narrow to prevent flame travelling upwards or downwards from the light-opening.

7. Cinematograph projectors shall be fitted with two metal film boxes of substantial construction, and not more than 14 inches in diameter, inside measurement, and to and from these the films shall be made to travel. The film boxes shall be made to close in such a manner, and shall be fitted with a film slot so constructed, as to prevent the passage of flame to the interior of the box.

8. Spools shall be chain or gear driven, and films shall be wound upon spools so that the wound film shall not at any time reach or project beyond the edges of the flanges of the spool.

9. During the exhibition all films when not in use shall be kept in closed metal boxes.

Lighting.

10. Where the general lighting of the auditorium and exits can be controlled from within the enclosure, there shall also be separate and independent means of control outside and away from the enclosure.

11. No illuminant other than electric light or limelight shall be used within the lantern.

Electric Light.

12.—(*a*) Within the enclosure the insulating material of all electric cables, including "leads" to lamps, shall be covered with fire-resisting material.

(*b*) There shall be no unnecessary slack electric cable within the enclosure. The "leads" to the cinematograph lamp shall, unless conveyed within a metal pipe or other suitable casing, be kept well apart both within and without the enclosure, and shall run so that the course of each may be readily traced.

(*c*) Cables for cinematograph lamps shall be taken as separate circuits from the source of supply, and from the supply side of the main fuses in the general lighting circuit, and there shall be efficient switches and fuses inserted at the point where the supply is taken, and in addition an efficient double-pole switch shall be fitted in the cinematograph lamp circuit inside the enclosure. When the cinematograph lamp is working, the pressure of the current across the terminals of the double-pole switch inside the enclosure shall not exceed 110 volts.

(*d*) Resistances shall be made entirely of fire-resisting material, and shall be so constructed and maintained that no coil or other part shall at any time become unduly heated.* All resistances, with the exception of a resistance for regulating purposes, shall be placed outside the enclosure, and, if reasonably practicable, outside the auditorium. If inside the auditorium, they shall be adequately protected by a wire guard or other efficient means of preventing accidental contact.

The operator shall satisfy himself before the commencement of each performance that all cables, leads, connections, and resistances are in proper working order. The resistances, if not under constant observation, shall be inspected at least once during each performance. If any fault is detected, current shall be immediately switched off, and shall remain switched off until the fault has been remedied.

* *E.g.*, they should not become so heated that a piece of newspaper placed in contact with any part of the resistance would readily ignite.

Limelight.

13.—(*a*) If limelight be used in the lantern the gas cylinders shall be tested and filled in conformity with the requirements set out in the Appendix hereto. The tubing shall be of sufficient strength to resist pressure from without, and shall be properly connected up.

(*b*) No gas shall be stored or used save in containers constructed in accordance with the requirements contained in the Appendix.

LICENCES.

14. Every licence granted under the Act shall contain specific conditions for the carrying out of regulations 2 and 5 (1) (*a*), (*b*), (*c*), (*d*), (*e*), (*f*), in the building for which the licence is granted, and may, in accordance with regulation 5 (2), contain an expression of opinion on the matters referred to in the proviso thereto.

15. Subject to the provisions of No. 16 of these regulations, every licence granted under the Act shall contain a clause providing for its lapse, or, alternatively, for its revocation by the licensing authority, if any alteration is made in the building or the enclosure without the sanction of the said authority.

16. Where a licence has been granted under the Act in respect of a moveable building, a plan and description of the building, certified with the approval of the licensing authority, shall be attached to the licence. Such a licence may provide that any of the conditions or restrictions contained therein may be modified either by the licensing authority or by the licensing authority of the district where an exhibition is about to be given. The licence and plan and description or any of them shall be produced on demand to any police constable or to any person authorized by the licensing authority or by the authority in whose

district the building is being or is about to be used for the purpose of an exhibition.

17. The regulations dated December 20th, 1909, made under the Cinematograph Act, 1909, are hereby repealed, provided, nevertheless, that any licence granted prior to such repeal shall remain valid for the period for which it was granted without the imposition of any more stringent condition than may have been imposed at the time of the grant.

Given under my hand at Whitehall this eighteenth day of February, 1910.

H. J. GLADSTONE,
One of His Majesty's Principal Secretaries of State.

APPENDIX.

LIMELIGHT.

The gas cylinders shall be tested and filled in conformity with the requirements set out below, which follow the recommendations of the Departmental Committee of the Home Office on the Manufacture of Compressed Gas Cylinders [C. 7952 of 1896] :—

Cylinders of Compressed Gas (Oxygen, Hydrogen, or Coal Gas).

(*a*) *Lap-welded Wrought Iron.* — Greatest working pressure, 120 atmospheres, or 1,800 lbs. per square inch.

Stress due to working pressure not to exceed 6½ tons per square inch.

Proof pressure in hydraulic test, after annealing, 224 atmospheres, or 3,360 lbs. per square inch.

Permanent stretch in hydraulic test not to exceed 10 per cent. of the elastic stretch.

One cylinder in 50 to be subjected to a statical bending test, and to stand crushing nearly flat between two rounded knife-edges without cracking.

(*b*) *Lap-welded or Seamless Steel.*—Greatest working pressure, 120 atmospheres, or 1,800 lbs. per square inch.

Stress due to working pressure not to exceed $7\frac{1}{2}$ tons per square inch in lap-welded, or 8 tons per square inch in seamless cylinders.

Carbon in steel not to exceed 0·25 per cent., or iron to be less than 99 per cent.

Tenacity of steel not to be less than 26 or more than 33 tons per square inch. Ultimate elongation not less than 1·2 inches in 8 inches. Test-bar to be cut from finished annealed cylinder.

Proof pressure in hydraulic test, after annealing, 224 atmospheres, or 3,360 lbs. per square inch.

Permanent stretch shown by water jacket not to exceed 10 per cent. of elastic stretch.

One cylinder in 50 to be subjected to a statical bending test, and to stand crushing nearly flat between rounded knife-edges without cracking.

Regulations applicable to all Cylinders.

Cylinders to be marked with a rotation number, a manufacturer's or owner's mark, an annealing mark with date, a test mark with date. The marks to be permanent and easily visible.

Testing to be repeated at least every two years, and annealing at least every four years.

A record to be kept of all tests.

Cylinders which fail in testing to be destroyed or rendered useless.

Hydrogen and coal gas cylinders to have left-handed threads for attaching connections and to be painted red.

The compressing apparatus to have two pressure gauges, and an automatic arrangement for preventing overcharging. The compressing apparatus for oxygen to be wholly distinct and unconnected with the compressing apparatus for hydrogen and coal gas.

Cylinders not to be refilled till they have been emptied.

If cylinders are sent out unpacked, the valve fittings should be protected by a steel cap.

A minimum weight to be fixed for each size of cylinder in accordance with its required thickness. Cylinders of less weight to be rejected.

STATUTORY RULES AND ORDERS, 1913

No. 566

CINEMATOGRAPH, ENGLAND

REGULATIONS, DATED MAY 20, 1913, MADE BY THE SECRETARY OF STATE UNDER THE CINEMATOGRAPH ACT, 1909 (9 EDW. VII., c. 30).

In pursuance of the power vested in me by the Cinematograph Act, 1909 (9 Edw. VII., c. 30), I hereby make the following regulations :—

LIGHTING.

1. Number 11 of the Regulations dated February 18th, 1910, made by the Secretary of State under the Cinema-

tograph Act, 1909, is amended so as to read as follows :—

> No illuminant other than electric light, limelight or acetylene shall be used within the lantern.

2. No acetylene shall be used unless supplied direct from cylinders or other vessels containing a homogeneous porous substance, with or without acetone, and unless as regards such vessels, their contents and the degree of compression, the following requirements of the Secretary of State's Order of the 6th August, 1912, under the Explosives Act, 1875, and the Order in Council of the 26th November, 1897, are complied with, namely :—

(1) The pressure shall not exceed one hundred and fifty pounds to the square inch.

(2) The porous substance shall fill, as completely as possible, the cylinder or other vessel into which the acetylene is compressed, and the porosity of the substance shall not exceed eighty per cent.

(3) Every cylinder or other vessel into which acetylene is to be compressed shall be thoroughly tested to a pressure of not less than double that to which the vessel is to be subjected in use, and shall be fitted with a fusible plug designed to act at or below a temperature of 212° F.

(4) Every cylinder or vessel in which acetylene is compressed shall be permanently and conspicuously marked with the name of the manufacturer and the words—"Acetylene compressed into porous substance exempted by Order of Secretary of State dated 6th August, 1912," and shall bear a label giving the date when it was last filled together with the name and address of the filler.

(5) When acetone is used for absorbing the acetylene due precaution shall be taken that the quantity of acetone is such that when fully charged with acetylene it does not completely fill the porosity of the porous substance.

Given under my hand at Whitehall, this 20th day of May, 1913.

R. McKenna,
One of His Majesty's Principal Secretaries of State.

CHAPTER X

COPYRIGHT

The Copyright Act, 1911

THE provisions of the Copyright Act, 1911, materially affect those engaged in the Living Picture industry. Under the law as it stood before the Act it was not an unknown thing for a person who was not the author to reproduce a film that had had a popular run and to put it on the market, and now that the process of reproduction is so much easier, it is very essential that film producers should have full protection for their productions.

Nature of Copyright.—This is explained in Section 1 of the Act as follows: "For the purpose of this Act, 'copyright' means the sole right to produce or reproduce the work, or any substantial part thereof, in any material form whatsoever, to perform, or in the case of a lecture to deliver, the work or any substantial part thereof in public; if the work is unpublished, to publish the work or any substantial part thereof; and shall include the sole right (*a*) to produce, reproduce, perform or publish any translation of the work; (*b*) in the case of a dramatic work, to convert it into a novel or other non-dramatic work; (*c*) in the case of a literary, dramatic, or musical work, to make any record, perforated roll, cinematograph film, or other contrivance by means of which the work may be mechanically performed or delivered, and to authorize any such acts as aforesaid."

Copyright protection is now entirely based upon the provisions of the Act, and all Common Law rights are

explicitly abrogated (Sec. 31). No registration or other formality is now necessary. The only conditions precedent for copyright protection in a work are—(1) That the work is original; (2) that it is a work of a character entitling it to protection; and (3) in the case of a published work, that it is first published in territory where the Act extends, and in the case of an unpublished work that the author is either resident in such territory, or is a British subject (Sec. 1 [1]). The above definition of copyright is about as wide as could possibly have been framed. Every original literary, dramatic, musical, and artistic work is protected (Sec. 1 [1]). Artistic works include photographs, so that inasmuch as cinematograph films are photographs they would appear to be subject to such provisions of the Act as apply to photographs. Protection is also definitely afforded to original dramatic works against cinematograph reproduction. The protection of dramatic works against reproduction by cinematography had hitherto been confined to such works in which there was some plot or story which could be reduced to writing. In an action (Karno *v.* Pathe Frères, 99 L.T., 114, and 100 L.T., 260) brought in 1908 by the author of a popular sketch called "The Mumming Birds," the defendants had made a film for which they engaged living persons whom they got up like the actors in the original sketch. The film was in all essentials a copy of the original sketch. It was held, however, as in a previous decision (Tate *v.* Fulbrook, 98 L.T., 706), that a pantomimical sketch substantially or mainly in dumb show, and without a definite story which could be written, was not a "dramatic work of entertainment" which was entitled to the protection given by the Dramatic Copyright Act, 1883. The latter Act is repealed by the present Act, and the definition of a "dramatic work" in Section 33 of the Act leaves hardly any room for doubt that the fullest protection is now intended to be afforded against cinematographic piracy of any dramatic

work whatsoever. A film showing pierrots on the shore or elsewhere would even appear to infringe the copyright which automatically subsists in any original piece being represented. An original piece for a dramatic film will also be protected against a copy or reproduction of the piece, whether produced as a film or as an acted piece; but the production of a film representing a story in which no copyright exists will not presumably prevent another person producing another film of the same story, so long as the latter production is an independent one, and not a mere copy of the first film. The photographer of any public event will have copyright in his negative, but cannot prevent the issue of a film or photos of the same event taken by another photographer.

Publication means the issue of copies to the public, but does not include the performance in public of a dramatic or musical work (Sec. 1 [3]). The photograph or film, or the musical record, as the case may be, must have been purchasable, or otherwise obtainable, from the manufacturer. It would probably be sufficient if only one copy or record is sold, or even if only one is offered for sale. The publication or issue must, however, be *bona fide*, and not colourable only (Sec. 35 [3]), and it must satisfy the reasonable requirements of the public. The publication must also be with the consent of the author or his executors or assigns (Sec. 35 [2]). Performance includes any acoustic representation of a work, and any visual representation of any dramatic action in a work, including such a representation made by means of any mechanical instrument (Sec. 35 [1]). Copyright will still subsist even though the work is not published, provided that the author is either a British subject or resident —*i.e.*, domiciled—in territory where the Act extends. If, however, the work is first published outside such territory, even though the author is a British subject, copyright will cease to exist, and cannot be revived in this country.

The condition as to first publication will also be complied with if the work is published in territory where the Act extends within fourteen days of publication elsewhere, or such longer period as may be fixed by Order in Council Sec. 35 [3]). In the case of an unpublished work the condition as to residence will be satisfied if the author is domiciled in any territory where the Act extends (Sec. 35 [5]), and where in the case of an unpublished work, the making of the work has extended over a considerable period, the conditions are satisfied if the author was, during any substantial part of that period, a British subject, or resident in any territory where the Act extends (Sec. 35 [4]).

Extension of the Act.—The Act extends throughout the United Kingdom, and, with the exception of provisions relating to summary remedies for infringement (Secs. 11 to 13) and the supply of books to libraries (Sec. 15), to all British Possessions other than the self-governing Dominions, (*i.e.*, Canada, Australia, New Zealand, South Africa, and Newfoundland). Provisions are made under which His Majesty may by Order in Council extend the Act to the self-governing Dominions, to territories under His Majesty's protection, to Cyprus, and to foreign countries (Secs. 25, 26). The Act will no doubt extend to all countries who were signatories to the articles of the Berlin Convention, and to such self-governing Dominions that adopt the Act. The latter have, however, a perfectly free hand. They may adopt the Act as it stands, or with such modifications or additions as relate exclusively to procedure and remedies, or are necessary to adapt the Act to the circumstances of the Dominion (Sec. 25 [1]). If a Dominion does not adopt the Act, either as it stands or modified as above, but confers rights substantially identical with those of the Act upon works of British subjects or residents in any country where the Act extends, the Secretary of State may certify to this effect, and the Act will

extend to the Dominion, notwithstanding that the remedies for enforcing the rights, or that the restriction on the importation of copies of works manufactured in a foreign country differ, under the law of the Dominion, from those under the Act (Sec. 25 [2]). If alternatively the law of the Dominion provides adequate protection for the works of British subjects outside the Dominion, His Majesty may, by Order in Council, for the purpose of giving reciprocal protection, extend the whole or any part of the Act, and subject to any conditions to be stated in the Order, to works first published in the Dominion, and to authors resident at the time of making the work in the Dominion (Sec. 26). An Order in Council extending the Act or part thereof to any foreign country as the result of a treaty or convention will apply to British Possessions, but not, as hitherto, to the self-governing Dominions, unless the Governor of the Dominion makes a corresponding Order in Council (Sec. 30 [2]). All British Possessions to which the Act extends have the right at any time to pass supplementary legislation with regard to—(1) procedure and remedies; (2) works of authors who were at the time of making the work resident in the Possession; and (3) works first published in the Possession (Sec. 27).

Duration of Copyright and Authorship.—The term for which copyright subsists still depends upon the nature of the work. In the case of photographs the term is fifty years from the making of the original negative from which the photograph was directly or indirectly derived. The person who was the owner of the negative at the time when such negative was made is deemed to be the author of the work. Where such owner is a body corporate, the body corporate is deemed for the purposes of the Act to reside within the parts of His Majesty's Dominions to which the Act extends, if it has established a place of business within such parts (Sec. 21). These provisions materially simplify the calculation previously necessary.

The prescribed date from which copyright runs is the date on which the original negative was made, excepting where copyright already existed at the date on which the Act came into force—viz., July 1, 1912, in which case the date of the author's death is material. It cannot be said that the prescribed date is satisfactorily definite. The date of taking the negative would have been definite—viz., the date of exposure. The date of "making" might, however, not unreasonably be assumed to be the date on which the negative was finished—*i.e.*, in a condition for actual reproduction. Other special provisions are made for the duration of copyright in respect of works of joint authors (Sec. 16), posthumous works (Sec. 17), Government publications (Sec. 18), and "records," perforated rolls, and other contrivances by means of which sounds may be mechanically reproduced (Sec. 19). In the latter case the term is fifty years from the making of the original plate from which the contrivance was directly or indirectly derived, and the person who was the owner of such original plate at the time when such plate was made is deemed to be the author of the work. In all other cases the term for which copyright subsists is the life of the author and fifty years after his death (Sec. 3). There is, however, a proviso that at any time after the expiration of twenty-five years, or thirty years in the case of a work in which copyright subsists on July 1, 1912, from the death of the author of the work, copyright shall not be deemed to be infringed by any person who reproduces the work for sale, if certain regulations are observed in a manner to be prescribed by the Board of Trade. These are—(1) That the person has given notice in writing of the intention to reproduce the work; and (2) has paid to or for the benefit of the owner of the copyright royalties in respect of all copies sold and calculated at the rate of 10 per cent. on the price at which the reproduced work is published. This proviso would probably be of interest to the film-producer only in the case of literary and dramatic works,

In the case of a dramatic film, when an original plot or story is associated with the film, as it now so often is, the copyright in the film itself, as a photographic reproduction, would appear to expire before the copyright in the plot as a dramatic work; but a reproduction of the film derived directly or indirectly from the original negative would apparently infringe the copyright in the plot, even after the expiration of the period of fifty years from the making of the original negative, until the copyright in the plot has expired. The case of photographs (*e.g.*, picture films) in which copyright existed on July 1, 1912, also is peculiar. Prior to the Act copyright in photographs subsisted until seven years after the author's death. Thus, where an author was alive on July 1, 1905, and the negative was made within fifty years of July 1, 1912 (*i.e.*, subsequent to July 1, 1862), the copyright will continue to subsist until fifty years from the date on which the original negative was made; but there will apparently be no copyright in a film the author of which died on or before July 1, 1905. The author of a photograph was, prior to the Act, and will be, for the purposes of determining whether copyright existed on July 1, 1912, the person who is immediately responsible for the picture as it is when it is made (Nottage *v.* Jackson, [1883], 11 Q.B.D., 632). If copyright subsisted on July 1, 1912, it will continue to subsist until the expiry of fifty years from the date on which the original negative was made, whether it is published or not.

The Act has made a substantial alteration in the law as to the author of a photograph. The author after July 1, 1912, is deemed to be the owner of the negative at the time it was made (Sec. 21). The author will not thus be the cinematographer who is an employee, or who parts with his ownership in the negative before it is "made" (*i.e.*, ready for reproduction). It is to be noted that when copyright in any work once subsists,

it cannot be destroyed, but subsists automatically for the period provided.

Ownership of Copyright.—In the case of photographs, films, and records, perforated rolls, and other contrivances for mechanically reproducing sounds, the owner of the original negative or mechanical plate or means, as the case may be, when the same is made, is deemed to be the author of the work (Secs. 21, 19 [1]), and is the first owner of the copyright (Sec. 5 [1]), excepting in three circumstances. (1) Where, in the case of a photograph, the plate or film is ordered by some person and is made for valuable consideration, then, in the absence of any agreement to the contrary, the person by whom the work was ordered is the first owner of the copyright (Sec. 5 [1] [*a*]). It will, no doubt, become quite an ordinary thing for a cinematographer to be in requisition for private and other special events, where hitherto the photographer has been in attendance. Again, both amateur and professional cinematographers will have occasions to seek permission to photograph. In both cases, unless there is a definite order for valuable consideration, and the circumstances are indisputably clear, it will be advisable to have a definite agreement in writing (although writing would not appear to be absolutely necessary) as to the copyright. Otherwise, as has previously happened in the case of ordinary photography, it may be a matter of difficulty to determine from the circumstances who is the owner of the copyright. Actual payment of consideration for the order is not, however, a condition precedent to vest the copyright in the person ordering, nor need the consideration be a money payment (Boucas *v.* Cooke [1903], 2 K.B., 227). Ownership of the copyright is not the same thing as ownership of the negative. The person executing an order for valuable consideration will still, subject to any agreement, have the right to retain the possession of the negative, but will not be able to

reproduce from it unless in execution of a further order, or by agreement with the owner of the copyright. (2) Where the author is an employee under a contract of service, or is an apprentice under a contract of apprenticeship, and the work is executed in the course of employment, the employer is the first owner of the copyright (Sec. 5 [1] [*b*]). (3) The ownership of the copyright may be a matter of agreement. The owner may assign his copyright either wholly or partially, and subject to limitations in respect of time and place, or he may grant any interest in the right by way of licence (Sec. 5 [2]). Such assignments and licences must be in writing, and signed by the owner of the right, or by his duly authorized agent (Sec. 5 [1]).

No rights can apparently pass except by means of a written document. The sale, for example, of a film or even of the original negative does not apparently in itself operate to pass any property or rights in the copyright. Where the author of a work is the first owner of the copyright, no grant or assignment of the copyright, or of any interest therein made by him (otherwise than by will), can operate to vest in the assignee or grantee any rights in the copyright beyond the expiration of twenty-five years from the death of the author. The reversionary interest after that period vests in his legal personal representatives as part of his personal estate, and an author cannot, moreover, contract out of this provision of the Act (Sec. 5 [2]).

Infringement of Copyright and Remedies Therefor. — "Copyright in a work is deemed to be infringed by any person who, without the consent of the owner of the copyright, does anything, the sole right to do which is by the Act conferred upon the owner of the copyright" (Sec. 2 [1]). The nature of these rights has already been considered. There will be infringement, whether or no the infringement takes place knowingly or innocently; but an infringer who can prove that he had no

reasonable grounds for suspecting that copyright existed in the work, and that the infringement was innocent, is exempted from liability in damages, and the plaintiff is not entitled to anything more than an injunction or interdict, and the possession of infringing copies and all plates (which would presumably include negatives) used, or intended to be used, for the production of infringing copies (Secs. 7, 8). A person will be deemed to infringe if he authorizes any infringement, and the ordinary rules applicable to master and servant will apply in determining whether there is authorization. The consent of the owner of the copyright operates to absolve the otherwise infringer from liability, and the consent need not apparently be in writing. It might even be implied if the conduct of the owner warranted this assumption. In addition to direct acts of infringement, there are other acts which, although they are not direct acts of infringement, are deemed to be acts of infringement. They are set out in Sec. 2 of the Act as follows :—

Copyright in a work shall also be deemed to be infringed by any person who :—

(*a*) Sells or lets for hire, or by way of trade exposes or offers for sale or hire ; or

(*b*) Distributes either for the purposes of trade or to such an extent as to prejudicially affect the owner of the copyright ; or

(*c*) By way of trade exhibits in public ; or

(*d*) Imports for sale or hire into any part of His Majesty's Dominions to which this Act extends, any work which to his knowledge infringes copyright or would infringe copyright if it had been made within the part of His Majesty's Dominions in or into which the sale or hiring, exposure, offering for sale or hire, distribution, exhibition, or importation took place.

Copyright in a work shall also be deemed to be infringed by any person who, for his private profit, permits a theatre or other place of entertainment to be used for the performance in public of the work without the consent of the owner of the copyright, unless he was not aware, and had no reasonable ground for suspecting, that the performance would be an infringement of copyright (Sec. 2 [3]).

A performance includes any visual representation of any dramatic action in any work (Sec. 35 [1]), and will thus include a cinematograph performance. Unless the owner of the copyright has consented to the performance, it is necessary, in order to evade liability, to prove not only innocence, but also that there was no reasonable ground for suspecting an infringement. A "performance in public" is one to which the public are invited as distinguished from a private performance. (Caird *v.* Sime [1887], 12 App. Cases, 326). The above provisions considerably modify the law as it existed before the Act came into force, and a person selling an infringing film of a work, knowing it to be such and intended for public performance, although he does not cause the piece to be represented, will now incur full liability. A person knowingly dealing with infringing copies in the manner stated above is liable, on summary conviction, to a fine not exceeding £2 for every copy dealt with, but not exceeding £50 in respect of the same transaction. In the case of a second or subsequent offence the penalty is a similar fine or imprisonment for a term not exceeding two months (Sec. 11 [1]).

A summary remedy is also provided against a person who knowingly makes or has in his possession any plate (which includes a negative) (Sec. 35 [1]) for the purpose of making infringing copies of the copyright work, or knowingly and for his private profit causes the work to be performed in public without the consent of the owner of the copyright. The penalty on conviction is a fine not

exceeding £50, and in the case of a second or subsequent offence, the same fine or imprisonment, with or without hard labour, for a term not exceeding two months (Sec. 11 [2]). The term "copy" and "infringing copy" constantly occur in the Act. No definition is given of what a copy is, but infringing when applied to a copy means any copy, including any colourable imitation, made or imported in contravention to the provisions of the Act (Sec. 35 [1]). It is in contravention to the Act "to reproduce the work or any substantial part of the work in any material form whatsoever," and a copy of any substantial part of the work in which copyright subsists would thus appear to be an "infringing copy," equally as a copy of the whole work. A film of a literary and dramatic work would also thus appear to be an infringing copy. A reproduction of any one of the separate pictures in a cinematograph film might possibly be held to be a substantial part of the film. In a case under the old Act of 1862 the plaintiff moved for and obtained an injunction against the defendant who had reproduced one face from a whole group (London Stereoscopic Company *v.* Kelly [1888]; 5 T.L.R., 169). Whether or no a summary conviction is obtained, the court may order that all copies of the work or all plates (including negatives or films) in the possession of the alleged offender, which appear to it to be infringing copies or plates for the purpose of making infringing copies, shall be destroyed or delivered up to the owner of the copyright, or otherwise dealt with as the court may think fit (Sec. 11 [3]).

In addition to such summary remedies, which are in the nature of criminal prosecutions, the owner of the copyright has civil remedies against an infringer. "Where copyright in any work has been infringed, the owner of the copyright shall, except as otherwise provided by the Act, be entitled to all such remedies by way of injunction or interdict, damages, accounts, and otherwise as are or

may be conferred by law for the infringement of a right" (Sec. 6 [1]). "The costs of all parties in any proceedings in respect of the infringement of copyright shall be in the discretion of the court" (Sec. 6 [2]). "In any action for infringement of copyright in any work, the work shall be presumed to be a work in which copyright subsists, and the plaintiff shall be presumed to be the owner of the copyright, unless the defendant puts in issue the copyright, or, as the case may be, the title of the plaintiff; and where any such question is in issue then—(*a*) if a name purporting to be that of the author of the work is printed or otherwise indicated thereon in the usual manner, the person whose name is so printed or indicated shall, unless the contrary is proved, be presumed to be the author of the work; (*b*) if no name is so printed or indicated, or if the name so printed or indicated is not the author's true name or the name by which he is commonly known, and a name purporting to be that of the publisher or proprietor of the work is printed or otherwise indicated thereon in the usual manner, the person whose name is so printed or indicated shall, unless the contrary is proved, be presumed to be the owner of the copyright in the work for the purposes of proceedings in respect of the infringement of copyright therein" (Sec. 6 [2]). "All infringing copies of any work in which copyright subsists, or of any substantial part thereof, and all plates used or intended to be used for the production of such infringing copies, shall be deemed to be the property of the owner of the copyright, who may accordingly take proceedings for the recovery of the possession thereof or in respect of the conversion thereof" (Sec. 7). "Where proceedings are taken in respect of the infringement of the copyright in any work, and the defendant in his defence alleges that he was not aware of the existence of the copyright in the work, the plaintiff shall not be entitled to any remedy other than an injunction or interdict in respect of the

infringement, if the defendant proves that at the date o the infringement he was not aware, and had no reasonable ground for suspecting, that copyright subsisted in the work" (Sec. 8). In taking summary proceedings against an infringer the onus is thus on the plaintiff to prove that the offence was committed knowingly. In a civil action, however, the onus of proof is upon the defendant to prove not only innocence, but also that he had no reasonable ground for suspecting that copyright subsisted in the work at the time of infringement, otherwise he is liable to be mulcted in damages as well as restrained by injunction. An action in respect of infringement of copyright cannot be commenced after the expiration of three years next after the infringement (Sec. 10). A summary conviction must be brought within six months after the date of infringement.

CHAPTER XI

PAST, PRESENT, AND FUTURE

Review—Cinematography for science, education, and commerce —Finis.

THE inquiry has often been made, "Who was the inventor of the Living Picture?" This question has usually been answered, if answered at all, by dogmatic assertion or the presentation of isolated facts; there has been no attempt towards a logical determination of the problem in its widest sense. In the first place, some definition of terms is required. Let us determine what a Living Picture is. Where shall the line be drawn? If we consider it merely as a view presenting the illusion of motion, then we must go back to the early years of last century and attribute its origin to Plateau's Phenakistoscope. If we restrict our definition to views of photographic origin, Wenham's experiments in 1852 fulfilled our requirements sixty-three years ago. Should it be required that the photographic record be a true analysis of motion, then nearly fifty years have passed since Du Mont indicated the methods of chrono-photography. Finally, if it be suggested that the picture must last a definite and somewhat lengthy period, the images being secured at short intervals and in a very restricted space of time, we are compelled to admit the Living Picture as a phenomenon of comparatively recent growth; but it must not be forgotten that many views of one action, procured by photography and repeated for as long a period as required, were prepared far earlier

than any date which may be termed recent. And, further, it must not be ignored that the different stages quoted above led insensibly one to the other; each step was founded on the labours of previous workers, or at least rested on the same basis. No! emphatically No! There is not, there never was, an inventor of the Living Picture. Say that it grew from an infinitely small germ, as unlike its present form as the butterfly is unlike the egg from which it evolves; say that many minds have each contributed, and still are contributing, their mite towards the realization of that perfection yet to be attained; say that the Living Picture is the work of nineteenth-century civilized man—and the statement will be as true as any generalization can be. So far as a single inventor can be named, Plateau must be recognized as the originator of the pictorial method of producing an illusion of motion by means of persistence of vision. This in a double sense; for while the Phenakistoscope was the forerunner of all machines in which a rapidly moving picture was momentarily viewed (and this definition includes machines so late in time as Edison's Kinetoscope), yet Plateau's "Diable soufflant" was the first step toward all those forms of apparatus in which a picture is momentarily viewed while stationary. True the picture was not stationary, but the principle of differential speed between image and shutter was established.

And to whom could this invention be attributed with more satisfaction? There is no name in the history of physiological optics more worthy of honour than that of this philosopher. Born in 1801, Joseph Antoine Ferdinand Plateau devoted himself early in life to the study of optics, especially in their physiological aspect. At the age of twenty-eight, in the course of some experiments respecting the effect of light on the retina, he exposed his eyes for a considerable time to the full blaze of the sun. The result was blindness, from which, however, he temporarily

recovered. During this period of recovery he invented the Phenakistoscope, and in 1835 was appointed Professor of Physics at Ghent. Over a period of fourteen years his sight gradually deteriorated, and by the year 1843 he was totally blind. Yet in 1849 he invented his "Diable soufflant"; he continued his researches by the aid of relatives, who carried out his instructions for experiments to confirm his theories; he pursued his investigations into the domain of molecular physics; he retained his professorship, and died in harness, leaving works still unpublished behind him, at the ripe age of eighty-three. There is a magnificence in the idea of this blind man carrying on his work, sowing the seeds of pleasure to thousands in future generations by means of that sense of which he was himself totally deprived; there is developed a feeling of pride in human power when we think of a man from whose eyes the light was eternally shut out nevertheless converting the brief glimmer of passing events into permanent embodiment, and leaving to others an elaboration of that sense which was lost to him for ever.

Yet it must not be forgotten that Plateau's Phenakistoscope took its origin from investigations on Roget's researches, which in themselves had nothing whatever to do with Living Pictures. So also with the application of photography. Many experimented long before the necessary appliances were ready to their hand. Mr. Wenham tells us that in 1852 he obtained (by posing) a series of views of a man at work; but he also records that when the views were synthesized into motion the subject declared "he never worked like that!" Du Mont in 1861 seems to have first suggested chrono-photography, and Janssen apparently first practised it in 1874; but neither could work rapidly enough to obtain a series fit for recombination. The reproduction of animated scenes was thus not possible until photographic emulsions of greater rapidity were produced; manifestly photographic chemists and

plate-makers must receive acknowledgment of a large share in the invention of the Living Picture. Again, let the most rapid emulsion be spread on glass, it is difficult —almost impossible—to obtain an extended series of views. Bands were suggested for carrying a long series of pictures by Stampfer in 1833 and Desvignes in 1860; the idea was in constant evidence from that time forward, but how could it be applied in the taking of a photographic record? Negative paper, improved as it now is, possesses sufficient grain to render it practically useless as a support for one-inch negatives destined to great enlargement; it was still less suitable years ago. Evidently, therefore, the inventor of celluloid should receive his meed of praise, yet not he alone; celluloid was not invented for the service of the Living Picture—indeed, at first it was not suitable for photographic purposes at all. When rendered fit for use as a photographic support, the Living Picture in no way came into consideration; celluloid was applied at first in the ordinary manner as a substitute for glass plates of ordinary sizes.

Given a celluloid film of indefinite length, the road was opened for the inventors of mechanical appliances which should utilize it. Thus while we find Greene and Evans were the first to publish and produce an effective machine, yet it must not be forgotten that others were working too; in fact, Messrs. Donisthorpe and Crofts were not two months behind the previously mentioned inventors. Thus throughout the history of the Living Picture names are associated rather with details than with principles, which in fact seem generally to have been pointed out long before the means existed for carrying them to a practical issue.

In fact, throughout the course of last century the Living Picture was, in popular parlance, "in the air"; similar ideas and methods occurred independently, sometimes simultaneously to separate individuais, and this was almost

necessarily so; the facts of the case demanded it. Given a series of connected facts capable of leading in combination to one or two well-defined results; given a number of observers equally interested and of similar capability—it is a practical certainty that several will arrive at the same conclusion, the more so as the field of possibility becomes more restricted. In cases of this kind one observer may reach the obvious conclusion before another; that does not prove his right to a national memorial and entry on the roll of fame; there is credit due to the man who extracts a grain of sand from the machine and so renders it workable; he proves his industry and application, but certainly cannot claim recognition as a genius. In proportion as the elementary facts become more numerous and complicated, so does the discovery fall inevitably to the man of greater capability if the solution be reached by reasoning; if it be arrived at by accident, that is a matter personal to the discoverer—he is not bound to mention it!

To substantiate these views several examples taken from the history of Living Pictures can easily be quoted. Plateau and Stampfer invented the Phenakistoscope almost simultaneously. When we consider that the subject of wheel-phenomena had been before the world for some years, it is not surprising that the popular introduction of the Thaumatrope should have caused the idea of the Phenakistoscope to crystallize, so to speak, in the mind of more than one man. To come to later years, a comparison of Acres' English invention of May, 1895, with Müller's German patent of August in the same year, will show an almost similar method of dealing with the same problem. This is probably due to the fact that the solution was a fairly obvious one. Marey had done the same thing less perfectly in 1890; he clamped the film and allowed it to be drawn onward by a spring when the clamp was taken off; Acres and Müller put a roller on the end

of the spring. Certainly one device was effective, the other was not; but still in this, as in many other instances, no great natural secret was brought to light. Take another case, this time an application of the cinematograph. It was early recognized that the zoëtrope afforded a means of varying the apparent rate of movement of an object; photographs of birds in flight secured by Marey's photographic revolver were recombined at a slower speed in this manner, for the purpose of leisurely inspection. Yet the subject appears to have exercised a fascination of a wide-spread character. M. Guéroult thought it worth while in 1896 to demand the opening of a sealed packet, deposited with the Académie des Sciences in 1889, in order to prove that he first evolved the idea. Mach, Corday and others claimed to have photographed plants at long intervals, and subsequently combined the views rapidly; much ink was spilled, for the idea was "in the air"—it was of the obvious. If another case were required, it might be found in the province of colour photography.

Every step forward renders the area of known facts wider, and attention becomes more and more confined to detail. There exists an almost bewildering variety of mechanical devices directed to one end by several paths. Yet the practical stage is attained. If unquestionable accuracy is required, photography supplies it. Therefore the cinematograph becomes a recording instrument of historic importance, and a library or museum of sealed film negatives might become as important as the British Museum. History might verily be made to "live." As exemplifying the current aspect of history, it may be mentioned that a kinetogram of a Pope's promenade in the Vatican gardens has been considered far more effective than even an official bulletin as an antidote to rumours of ill-health. Yet "seeing is not always believing"; and rescues by lifeboat crews and desperate interior combats

in guerilla warfare must be taken with a proverbial grain of salt.

In practice there is no limit to the length of scene capable of reproduction. Indeed, one of the most important developments for entertainment purposes has been the production of such films as "Quo Vadis," "Hamlet," "Parsival," and other like productions, which are each an ample sufficiency for one evening. If sensation is demanded, one may have a strictly private exhibition of an execution per guillotine; but surely nothing more terrible could be desired by the most morbid mind than a view of a disaster at sea, the horrors of which are repeated before an audience at a music-hall (to the strains of "Rocked in the Cradle of the Deep"!) only thirty hours after the breath has left the victims' bodies. The question of "censorship" must always be a difficult one, and while, perhaps, it is, on the whole, well that this process should be applied from within, by a cinematograph association, than from without, by a Government or municipal official, yet there is still room for a more vigorous application of this process.

While the most extensive use to which cinematography has been put has been as a medium for entertainment, it must not be forgotten that cinematography is a science just as photography is a science. It is also an art, just as photography is an art. That this has not been sufficiently realized is only too often and painfully evident in the films that are held out as "attractions." It is a welcome sign of the times that Professor Herkomer and Marie Corelli, and other artists, have interested themselves in this sphere. It is also a welcome sign that an educational institution such as the Polytechnic, Regent Street, has instituted a school of cinematography. The Polytechnic is the birthplace of the magic-lantern, and one of the earliest cinematograph exhibitions was given there by arrangement with Messrs. Lumière of France. The School

of Photography, of which Professor Howard Farmer is principal, is the oldest school of its kind in existence, and its students are to be found all over the world occupying some of the most important positions. It is hoped that history may repeat itself in connection with cinematography.

Science also is utilizing cinematography to the full. The earliest use was for scientific purposes. Marey and Muybridge's early work was in connection with the flight of birds and the movements of persons and animals, and Jansen's astronomical work falls in the same category. The solar eclipse, as seen in India, was destined to reappear at command at a multitude of semi-scientific soirées, and it is not to be charged against the cinematograph that this pleasant anticipation was not realized—the undeveloped film was stolen on its journey home. Nowadays it would be developed on or before its journey home. Is it possible that in the future it might be copied at home by wireless? As another instance of the adaptation of the cinematograph to popular science it may be mentioned that, under M. Flammarion's direction, a large terrestrial globe was photographed during a rotation lasting two minutes. When projected, the effort, of course, was that of the earth, as it would be seen by an observer in space, but turning at an increased speed. The cinematograph has been used for the investigation of extremely rapid movements, such as occur during the flight of birds and insects, the flight of a projectile, and in which successive exposures at intervals of one ten-thousandth of a second, and even more rapid than this, are required. Such exposures have been obtained by the use of spark discharges across the secondary terminals of an induction coil. Such sparks emit a highly active photographic light. With such very rapid exposures a continuously moving film is possible, and in one apparatus (Fig. 266) by M. Bull, of the Marey Institute in France, the sensitive

film is on the periphery of a rotating drum, R. The axis of the drum carries an interruptor, I, comprising a series of contact bars, and by means of contact brushes the primary circuit P of the induction coil A is intermittently closed and opened. The secondary circuit of the coil supplies a spark light, E, with corresponding intermittence at intervals depending on the speed of rotation of the drum. The apparatus is fitted with a suitable shutter, M, to prevent a double set of images being taken by the continued rotation of the drum. The bird or object is enticed to move across the front of the condenser C, and apparently some little inducement is often necessary. Although taken at such rapid intervals, the films are only projected at the normal rate of sixteen a second, and thus a series

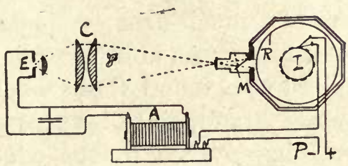


FIG. 266.

of exposures lasting only a few seconds may take several minutes to exhibit. The launch of a ship, or a girder subjected to breaking strain, form other subjects for this kind of research, and both these operations have been successfully photographed.

Cinematography by Röntgen rays is also being largely developed, and enormously enlarges the possibilities of the scientific use of cinematography.

En passant it may be mentioned that leisurely inspection of a film recording a feat by a celebrated conjuror results in a demonstration of "how the trick is done," "the quickness of the hand deceives the eye," but does not delude the impartial and accurate cinematograph.

Slow speed cinematography also has been largely devel-

oped, and utilized for portraying the development of flowers, eggs, and other slow processes of development. In this case the taking of the film may extend over days, and exposures made at intervals of several minutes. Such films are, however, reproduced at a normal rate, and a film which may have taken hours to produce may only take minutes to exhibit. Perhaps the most difficult scientific work is that of micro-cinematography, but considerable results have also been achieved in this sphere. Nature study, both in the open and in the laboratory, is a growing province for the cinematographic scientist, and the large stock of scientific films now available is conclusive evidence of the importance of this branch of the subject.

The use of the cinematograph for scientific purposes leads naturally to the much-debated question of its use for educational purposes. As in other spheres of activity, there are generally to be found those who take extreme views from opposite standpoints. There are some who have attached an importance to the educational value wholly out of proportion to the real value, and, on the other hand, there are those whose estimate is "worse than useless—positively harmful." The same phenomenon occurred in the early days of the magic-lantern. The ordinary lantern has, however, become indispensable for educational work. It has, of course, its own limitations. The cinematograph will not supplant the lantern, but it is undoubtedly a very great asset and advantage to be able to portray complete scenic panoramas, or a complete series of movements, or steps of a process, and especially where movement and change is of the essence of the study. With the lantern each slide only represents a fixed and definite view or phase of the process. It must be possible, for educational purposes, to be able to project any one picture of the cinematograph series, and a satisfactory non-flam film may therefore be regarded as an

absolute necessity. For extensive use in schools a celluloid film would be a source of danger, against which the possible utility would be a very inadequate compensation. The possibilities of the cinematograph for educational purposes is well illustrated by the films secured by Mr. Ponting on the South Polar Expedition with Captain Scott.

Commercially, too, the cinematograph has its uses. A series of films reproducing harvesting in Manitoba, for example, is doubtless a valuable method of encouraging emigration. A series of films representing the attractiveness of camp life might lead to a solution of the Territorial problem. There is no doubt but that a military audience finds great delight in witnessing the evolutions of foreign troops; but it may be doubted whether an accurate reproduction of the horrors of a battlefield would to any great extent facilitate recruiting; discretion is required in cinematography as well as in every other path of life. For the attractive display of fashions Kinemacolor is eminently adaptable, and for advertising generally the cinematograph has great potentialities.

From whatever standpoint cinematography is viewed, the future cannot safely be predicted, nor is it safe to prophesy. And why prophesy? Facts in the past remain facts in the present, but the future may be left to Fate. If a long course of actuality has had a somewhat sedative effect, if fiction is needed to restore a somewhat wearied brain, let us leave prophecy, which is so easily falsified by the reality of the future, severely on one side, and glance at a living picture of the weirdest type. In Flammarion's "Lumen," as also in a little work introduced to English readers by the late R. A. Proctor, the idea of persistence of light rather than persistence of vision is elaborated. Light and other vibrations, of which our limited perceptions afford no clue, travel from this earth into space at a definite velocity. So a continual

record of the earth's history in its slightest details is continually streaming off into the eternal void, and, granted an eye capable of perceiving an object under a minute angle, infinitely sensible also to vibrations, it will be seen that at some point or other in space everything that has happened is yet visible. Grant this eye, or rather sense of vision, a capability of infinite speed of translation, it might retreat at the same speed as light, and so keep the same event for ever in view; it might approach the outward travelling events and compress a lifetime into a moment. The whole history, not of this world alone, but of every sphere that is or has been, is still in vibrating existence, and one universal perception extending through the infinity would embrace within the tremblings of the boundless ether a consciousness of all that was or is, an eternal and universal living picture of all past events. Having started from persistence of vision due to the sluggish action of our mundane eyes or nerves, having lost ourselves in fancied possibilities of the illimitable, what remains for human thought and pen but the simple word

FINIS?

(*See Table of our Charges on page* 378)

APPENDIX I

PATENTS

THE development of cinematography is significantly reflected in the very large increase in the number of patents relating to the subject. A digest of patents such as was included in the first edition of the present work up to the year 1898 would necessitate a very large space, and it is doubtful if such a digest would be of great utility. Abridgments of all British specifications are published in the *Illustrated Official Journal*, and in separate volumes dealing with classified subject-matter, both publications being published by the Patent Office. Accordingly the subject has been divided up into its several branches substantially as dealt with in the text, and lists given of the principal specifications dealing with each branch of the subject.

In view of the extensive applications for Letters Patent, a few remarks on the subject may not be out of place. The grant of British Letters Patent is a grant from the Crown, and gives to the patentee of a new method of manufacture not the right to manufacture according to his invention, but the sole right to prevent anyone else from so doing, or from using or vending the product or process of the invention. The grant is given in consideration of the full disclosure of the invention to the general public, and therefore the invention must be particularly described and ascertained in the specification accompany-

ing the application. If the description is not a full and clear disclosure, and if important or essential information necessary for carrying out the invention is not disclosed, then the patent is *ipso facto* invalid. The grant is, in the first instance, for four years, after which a yearly renewal fee is payable by which the patent may be kept in force for fourteen years. In very rare instances, and only under very special circumstances, will the grant be extended beyond this fourteen years' limit. For such extension a petition heard before a Committee of the Privy Council is necessary.

Application for Letters Patent has to be made in the manner prescribed by the Patents and Designs Act, 1907, and by the Patent Rules, 1908, and has to comply with the requirements contained therein.

In the first instance a provisional specification may be filed with the application setting out the nature of the invention, in which case the complete specification, "particularly describing the nature of the invention and in what manner the same is to be performed," must be filed within six months, unless an extra fee of £2 is paid, in which case an extra month is allowed for filing the complete specification. The above course allows an interval for working out the details of an invention or any legitimate modifications or extensions thereof. The complete specification may, however, accompany the application.

The drafting of the specifications for a patent is in most cases by no means a simple or easy matter, especially for the uninitiated, and there are many pitfalls into which an unaided applicant may fall. In the large majority of cases, and especially where the invention is an important or complicated one, the professional services of an agent or expert are strongly to be advised.

The complete specification when filed is examined in the Patent Office, not only to see that the requirements with regard to formalities, description, and claims are

complied with, but a search is made through British specifications applied for within fifty years previous to the application to see if the same invention is wholly or in part described or claimed in any specification within this period. If the specification is not in order, or the search reveals an anticipation, the specification is returned to the applicant, and it devolves upon the applicant to amend the specification and to remove the objections raised. The search for novelty is not complete, and does not extend to foreign specifications nor to books and periodicals. When the application has been put in order and accepted, it has to run the gauntlet of an opposition, which must be based upon certain grounds defined in the Patents and Designs Act, 1907, and which must be lodged within two months after the acceptance of the specification opposed. After running this gauntlet successfully, the patent will be sealed in due course.

As regards initial cost, the stamp fee payable on filing an application is £1; that on filing the complete specification, £3; and that on sealing, £1. Other fees payable in respect of various processes, which may or may not be necessary in connection with Letters Patent procedure, are scheduled in the Patent Rules above referred to.

Foreign Patents.—The development of the cinematograph industry is eminently international. It may safely be asserted that practically every invention referring to cinematography having an admitted value in Great Britain is worth patenting abroad. The French, American, Italian, Danish, and German patents are particularly valuable in the case of that industry, although the extension of the cinematograph all over the world makes every invention connected with it of international value.

There is between the principal countries an International Convention, or reciprocal arrangement, whereby the applicant for a patent in Great Britain has, for the period of one year from the date of his application, the right to

apply for a patent in any of the countries which are parties to the arrangement, and to obtain priority for his invention over any other person who may have filed a competitive application during the said period.

The applicant in this country may, therefore, defer for one year the prosecution of his foreign patents, although it is better to apply for them as soon as the experiments, or the commercial results achieved, enable him to ascertain the probable value of his invention. In some foreign countries, such as Germany, Denmark, and America, a patent is obtainable only in cases where a very thorough search of the home and foreign records made by the Patent Office fails to reveal any anticipation of the invention. In other countries, such as France, Italy, etc., a patent is always granted, but its validity may be affected by any lack of novelty.

For a British applicant the prosecution of an application abroad presents even more difficulties and intricacies than in the case of a British application, and the professional services of an agent or expert is therefore almost a matter of necessity. Many agents are willing, also, to negotiate the foreign rights, and are in touch with foreign firms and agencies likely to be interested in the invention.

LISTS.

N.B.—These lists may not be complete in respect of patents filed during the last three months of 1913 and in 1914.

(1) Plate, disc, and cylinder apparatus; phenakistoscopes; zoetropes; apparatus with pictures in rows or spiral formation on wide films; and miscellaneous magic-lantern slides having devices for animated movement.

1853: 711. **1856:** 1245, 1965. **1859:** 2258. **1860:** 537. **1865:** 1588. **1867:** 629. **1869:** 745. **1877:**

4244. **1890**: 4978. **1892**: 15709, 23042. **1893**: 12794, 24031. **1895**: 9881, 19331. **1896**: 359, 18884. **1897**: 2204, 4811, 23231, 27505. **1898**: 6515, 17287. **1899**: 3266, 17952. **1900**: 311, 1643, 18364. **1901**: 18324. **1903**: 24231. **1904**: 17347. **1905**: 1517, 9406, 20570, 25973. **1906**: 9370, 9987, 11168, 19343. **1907**: 623, 13407, 14493, 20863. **1908**: 3987, 4040, 7306, 14837. **1909**: 453, 483, 3443, 9262, 16441, 17021, 19833, 21801, 21891, 27520, 27642. **1910**: 1140, 1546, 12574, 21828. **1911**: 13400. **1912**: 7582, 11197, 11351, 20058, 29417, 29478. **1913**: 13733, 13734, 13735, 20365.

(2) Book-form apparatus and other apparatus in which the successive pictures are on separate sheets. (See pp. 37-41.)

1868: 925. **1886**: 7717, 14917. **1890**: 10769. **1892**: 20281. **1895**: 14439, 18317. **1896**: 20136, 23183. **1897**: 8572, 12391, 13826, 18610, 22763. **1898**: 8338, 12415, 13143, 20219, 20802, 23158, 26722. **1899**: 2528, 9954, 11675, 12497, 13422, 16326, 16671, 16713, 23217, 25486. **1900**: 1319, 1320, 5451, 9141, 11745, 17076. **1901**: 9879, 12635, 14414, 24591. **1902**: 14602, 12612. **1904**: 21540, 22999. **1906**: 7403. **1908**: 134. **1910**: 5025. **1911**: 10265. **1912**: 3884, 5905, 7029, 14148, 15166, 19388, 17664.

(3) Film apparatus, continuously moving film type. (See p. 107 *et seq.*)

1889: 2295. **1896**: 4841, 11639. **1897**: 12175, 12911. **1898**: 4661, 11219, 16812, 20603, 22713, 24735. **1899**: 2575, 6793, 8245, 8246. **1900**: 7035, 7684, 9739, 12820, 23339. **1901**: 7650, 9291, 18324, 23564. **1902**: 846, 19254. **1903**: 3633, 12366. **1905**: 7482. **1907**: 18945, 26107. **1908**: 18783. **1911**: 8791, 18352, 28386.

1912 : 8100, 16881. **1913 :** 8062, 15621, 16201, 29238, 29466. **1914 :** 5268.

(4) Film apparatus, intermittently moved film type, maltese-cross and other film feed-mechanism for, having a wheel interacting with teeth or pegs. (See p. 117 *et seq.*)

1888 : 423. **1896 :** 359, 4686, 6503, 7817. **1897 :** 1039, 6536. **1898 :** 18135, 24290. **1899 :** 487, 12835, 17952. **1900 :** 10050, 14789. **1902 :** 11317. **1903 :** 5462. **1904 :** 9441. **1907 :** 14056. **1908 :** 23811, 27256. **1909 :** 7463, 15693. **1910 :** 2493. **1911 :** 1841, 9150, 12774, 14573, 21690, 23890. **1912 :** 2755, 7077, 20058, 24405. **1913 :** 16353, 16354, 19951, 20928. **1914 :** 637, 14986.

(5) Film apparatus, intermittently moved film type, film feed-mechanism for, having interaction of a pin or pin-teeth with a worm or cam. (See p. 131.)

1896 : 3777, 6731, 8418, 10778, 14455, 16080, 17049, 19446. **1897 :** 22558. **1898 :** 5485, 6515, 21371. **1899 :** 3274. **1900 :** 311. **1909 :** 453. **1911 :** 13400.

(6) Film apparatus, intermittently moved film type, film feed-mechanism for, with raising and lowering film sprocket-rollers. (See p. 135.)

1889 : 12921. **1896 :** 15603, 17224, 21381.

(7) Film apparatus, intermittently moved film type, film feed-mechanism for, having ratchet, clutch, friction, and like gearing. (See p. 137.)

1889 : 10131. **1895 :** 17930. **1896 :** 7809, 10006, 11836, 12128, 17881, 21382, 26765. **1897 :** 212, 7635, 10603, 19278, 19805. **1898 :** 441. **1900 :** 13883. **1902 :** 19481, 20773. **1903 :** 23474. **1904 :** 17347. **1905 :** 9406. **1908 :** 7414. **1913 :** 10282.

(8) Film apparatus, intermittently moved film type, film feed-mechanism for, comprising rollers periodically gripping the film. (See p. 139.)

1896: 15603, 17848. **1897:** 5995, 16388, 27038. **1898:** 18643. **1899:** 21754, 21755, 21756. **1902:** 20773. **1903:** 26579. **1904:** 11821. **1907:** 7277. **1910:** 15550. **1911:** 14550. **1912:** 11600, 14771, 25137, 25650. **1913:** 16941.

(9) Film apparatus, intermittently moved film type, film feed-mechanism for, of "claw" type. (See p. 142.)

1895: 7187, 12458. **1896:** 7801, 12128, 13642, 15603, 17848, 19181, 22627, 22707, 27585, 28799. **1897:** 1216, 5026, 6202, 17248, 18014, 25625, 27542. **1898:** 8362, 13162, 14965, 17831, 23591. **1900:** 2133, 2283, 18364. **1902:** 11317. **1906:** 12072, 18962. **1907:** 14058. **1908:** 3798, 11551, 21787. **1909:** 4534, 8548, 12571, 21217. **1910:** 7073, 9898. **1911:** 26947. **1912:** 16688, 24859. **1913:** 3019, 27359. **1914:** 5502.

(10) Film apparatus, intermittently moved film type, film feed-mechanism for, having a revolving dog or eccentric. (See p. 147.)

1893: 24457. **1896:** 359, 22627, 22928. **1897:** 886, 12785. **1898:** 9738, 12939, 15195. **1905:** 10602, 16925. **1908:** 5336, 8758. **1910:** 25074. **1911:** 15542, 25868. **1913:** 10519, 29436.

(11) Film apparatus, intermittently moved film type, film feed-mechanism for, having a reciprocating arm acting on the film. (See p. 148.)

1890: 4704. **1893:** 22954. **1895:** 10474, 18695. **1896:** 13284, 17224, 17505, 22928. **1897:** 1216, 14861, 24273. **1898:** 681, 10685. **1902:** 22423. **1908:** 20191. **1909:** 11546, 13030.

(12) Film apparatus, intermittently moved film type, film feed-mechanism for, having film gripping-blocks and other miscellaneous mechanisms not included in the above lists. (See p. 150.)

1896: 15603, 22627. **1897:** 5995, 11273. **1898:** 8362, 18643, 22976. **1901:** 22042. **1905:** 11622. **1910:** 5025. **1913:** 15150. **1914:** 3214.

(13) Films, the base; perforating systems for; special arrangements of pictures on (other than rows or spiral formations on plates or wide films); films of special photographic character or having other peculiar characteristics, not including arrangements and devices for colour, panoramic, stereoscopic, or synchronizing purposes. (See p. 155 *et seq.*)

1888: 16785. **1893:** 22954. **1896:** 7801, 7817, 10006, 13642, 17224. **1897:** 7635. **1898:** 12939, 22976, 24735. **1899:** 620, 12152, 17164, 17165. **1900:** 18364. **1901:** 9291. **1902:** 11317, 12818. **1903:** 5462. **1906:** 11762. **1907:** 3119, 9391, 20836, 24225, 25165, 26107. **1908:** 8542, 16114. **1909:** 13328, 14039, 14343, 14407, 14743, 14824, 14950, 19028, 19319, 20770, 20965, 21467, 21801, 21891, 24556, 27520, 27642. **1910:** 3603, 5025, 17872, 18851, 23688, 27482. **1911:** 493, 2500, 10138, 13400, 21608, 23386, 27173, 29163. **1912:** 2004, 3047, 3385, 4043, 4044, 4045, 4918, 5087, 6289, 8866, 14133, 14665, 16808, 17385, 17891, 18098, 18431, 19854, 23995, 25084, 29112, 29113, 29616. **1913:** 810, 1339, 2992, 4096, 4603, 4957, 5551, 6727, 7522, 9916, 10282, 10401, 13088, 17978, 22430, 25066, 26640. **1914:** 3214.

(14) Cameras, specially fitted for intermittently moved films, including arrangements for focussing, etc., and lens copying apparatus. (See p. 166.)

1893: 10474, 12458, 17930, 22954. **1895:** 18659. **1896:** 10006, 16080. **1897:** 5995, 12052, 12785. **1898:**

12939, 18643, 22976, 23591. **1899:** 21754, 21755, 21756. **1903:** 26579. **1904:** 22954. **1905:** 6436. **1908:** 3798, 5336. **1909:** 7463, 12571, 21217. **1910:** 6023, 11312, 22286, 23032. **1911:** 12538, 14550, 15542, 19644, 22985, 23505, 24751, 24859, 26949, 28754. **1912:** 3048, 8858, 9829, 10273, 11600, 14771, 15542, 17483, 24859, 29478. **1913:** 4096, 11183, 15219, 16353, 16354.

(15) Developing, fixing, washing, toning, cleaning, renovating, and other like treatments for films, and including film examiners. (See pp. 176-181 and 189 *et seq.*)

1886: 16327. **1894:** 6866. **1896:** 19726. **1897:** 19039, 21679, 23897, 25933. **1898:** 13315. **1899:** 22614. **1901:** 21873. **1902:** 1846, 9842, 11596. **1907:** 5413. **1908:** 2076, 16115. **1909:** 2954, 14472, 14743, 14824, 15841, 20965. **1910:** 2494, 11822, 11935, 16480, 23553. **1911:** 20015, 27173, 28366. **1912:** 4392, 12231, 14433, 18098, 24138, 28875. **1913:** 8581, 10401, 10909, 17290, 18852, 26263, 26787, 26788. **1914:** 2326, 2622, 9968, 9973.

(16) Printing apparatus for printing on long bands, continuously moving film type (not including continuously moving film cameras or projectors stated to be applicable for printing and universal purposes). (See pp. 182-185.)

1881: 1881. **1895:** 13317. **1896:** 21383. **1897:** 17633, 17634, 18699. **1898:** 13315. **1899:** 20024. **1900:** 10282. **1901:** 21248. **1902:** 4780, 22941. **1903:** 3765, 5500, 8113, 12677, 25048. **1904:** 3382, 20386, 21367. **1905:** 1753, 1757, 17605, 26740. **1906:** 8239, 9764, 15574, 16390, 24851. **1907:** 8817, 10358, 19408. **1908:** 2076, 5810, 11745. **1910:** 28926. **1911:** 10701, 10702, 19743, 21834, 26997. **1912:** 3384, 5278, 14433, 14957, 18230, 18728, 29514, 29515. **1913:** 9865, 18341, 25703.

(17) Printing apparatus for printing from film negatives, intermittently moved film and other types (not including film cameras or projectors stated to be applicable for printing and universal purposes). (See pp. 185-189.)

1898: 13315. **1899:** 1795. **1900:** 2283, 16958. **1901:** 20388. **1904:** 29051. **1909:** 25724, 29594. **1910:** 23553. **1912:** 7182, 26173, 29512, 29700. **1913:** 6886.

(18) Film apparatus (chiefly projectors having an intermittently fed film, *cf.* pp. 198-203): driving mechanisms and gearing arrangements in (other than film feed-mechanisms); spooling, threading, and take-up devices for (including endless film systems and apparatus, and apparatus in which no rewinding is necessary); including also film spools and reels; spool-boxes (other than constructions for preventing and minimizing fire); and winders and rewinders.

1889: 10131, 12921. **1890:** 4704. **1896:** 359, 4686, 4841, 7801, 13284, 14455, 16080, 17224, 17505, 17881, 19181, 19446, 22627, 22707, 22928. **1897:** 1039, 11923, 14861, 16388, 17747, 18014, 19278, 24273, 27038, 27542. **1898:** 681, 10685, 11219, 15195, 17805, 18135, 18643, 20603, 24290. **1899:** 1382, 3274, 21754, 21755, 21756, 22954. **1900:** 2133, 10050, 12820, 13883, 15226. **1901:** 15083. **1902:** 20773, 22423, 27240, (?) 27440. **1903:** 26579. **1904:** 9441, 11821. **1905:** 24426. **1907:** 7277, 23008, 24120. **1908:** 7620, 8758, 11998, 27256. **1909:** 3048, 8338, 11546, 27675, 29684. **1910:** 1876, 4384, 6812, 8058, 11312, 19148, 20516, 22286, 23032, 25074, 25252. **1911:** 1841, 4643, 13564, 14916, 20675, 21690, 24992, 27173, 27793, 28754. **1912:** 2004, 2755, 3048, 6104, 8858, 10273, 13492, 13920, 18684, 20058, 23964, 24138, 25650, 28917, 29417, 29478, 29746. **1913:** 4416, 4603, 4957, 10519, 12513, 14237, 15151,

15220, 15863, 16047, 16382, 17289, 18360, 20928, 21142, 23209, 27759.

(19) Film apparatus (chiefly projectors having an intermittently fed film): film gates and guides in, and picture and optical centering devices for. (See p. 213.)

1896: 11639, 16080, 17224, 17881, 22928. **1897**: 12785, 27038. **1898**: 681, 17805. **1899**: 6793. **1900**: 1467, 5292, 7668, 12820, 13883, 15226, 13339. **1902**: 19254, 22423. **1904**: 9441, 11821. **1905**: 10602, 16925. **1906**: 16771, 22429, 23904. **1907**: 15459, 19892, 22109, 24157. **1908**: 11968, 23274, 23275, 23811. **1909**: 9864, 27675. **1910**: 2493, 4863, 7073, 7816, 10779, 11312, 18555, 25252, 27784. **1911**: 1841, 3629, 9150, 25868. **1912**: 9829, 10273, 10475, 11600, 13006, 13492, 16881, 16888, 20058, 25137, 25161, 26820, 28917, 29417, 29478. **1913**: 4362, 5535, 6061, 8581, 16201, 16353, 16914, 17289, 21570, 21948, 21969, 23994, 26452 27358, 29238. **1914**: 10951.

(20) Shutters and intermittent illumination arrangements, including devices for switching the projecting light off and on, and for maintaining a constant illumination on the screen. (See pp. 229-236.)

1889: 12921. **1893**: 22954. **1895**: 12458. **1896**: 3777, 7801, 10006, 10778, 15603, 17224, 17848, 22627, 26765, 28799. **1897**: 888, 1216, 6536, 10603, 12785, 14851, 17248, 19805. **1898**: 681, 12939, 17805, 18135, 20603, 21371, 22976, 24290. **1900**: 12820, 13883, 18364. **1902**: 11317, 19481. **1904**: 11821, 22954, 29051. **1908**: 7414, 12059, 13027, 20191, 22117. **1909**: 11546, 27675, **1910**: 7815, 24822, 29832. **1911**: 1841, 9552, 12774, 23195, 23890. **1912**: 2338, 8858, 13492, 14771, 14880, 17483, 18771, 25142, 28917. **1913**: 3509, 5440, 10519, 12411, 16010, 16047, 16941, 20928, 21142, 22430, 29436. **1914**: 273, 2490, 9043.

(21) Screens. (See p. 213.)

1886: 1980. **1896**: 21269. **1897**: 12774. **1898**: 1835. **1899**: 9005. **1903**: 9869. **1908**: 17285, 27376. **1909**: 3762, 18093, 30059. **1910**: 12037, 15661, 16104, 27069. **1911**: 17771, 20836, 24917, 28081, 28823, 28838. **1912**: 15008, 17276, 24547. **1913**: 4263, 6064, 16989, 17871, 26452, 28701, 28702. **1914**: 4679, 8805.

(22) Fire preventing and minimizing devices for projectors. (See p. 236.)

1884: 14951. **1896**: 16080. **1897**: 11923. **1898**: 9374, 10047, 17805, 23099. **1900**: 7668, 21545. **1902**: 22423. **1904**: 1211, 11821. **1905**: 15003, 24426. **1906**: 5626, 24953, 25798. **1907**: 10078, 15459, 15902, 22874, 44525. **1908**: 563, 9711, 11395, 13663, 16420, 21308, 25666, 27120, 27256. **1909**: 147, 3048, 7184, 9876, 14322, 22494, 29117. **1910**: 2168, 8058, 9911, 14650, 15550, 18851, 18928. **1911**: 1841, 2444, 4514, 19078, 25636, 27723. **1912**: 4639, 10273, 13492, 14880, 18771, 19042, 20059, 23085, 23206, 28917. **1913**: 629, 5437, 5884, 7325, 10519, 12334, 16047, 16201, 16941, 27645, 27759. **1914**: 11969.

(23) Panoramic and stereoscopic cinematography, and miscellaneous screen and scenic arrangements for producing relief or other special effects. (See pp. 244, *et seq.*)

1886: 15192. **1894**: 16326, 22990. **1897**: 886, 17565, 24804. **1898**: 1835, 3477, 13036, 13644, 24290. **1899**: 1382, 3274, 6794. **1900**: 7035, 13883, 21985. **1901**: 4309, 10695, 18324, 20173. **1902**: 10695. **1903**: 1483, 9896, 10277, 12997, 13410, **1904**: 1090. **1905**: 3998, 4423. **1907**: 1969, 15726, 17710, 17955, 23396, 25741. **1908**: 2584, 4829, 7897, 8963. **1909**: 14834, 30059. **1910**: 12037, 23163, 27069. **1911**: 839, 840, 3552, 8752, 12891, 19823, 22910. **1912**: 10870, 12797, 15008, 20507,

24945, 26820, 29495, 30666. **1913:** 971, 1339, 4925, 6557, 7344, 11048, 11950, 19929, 20888, 26452, 29875. **1914:** 4679, 5212, 12249.

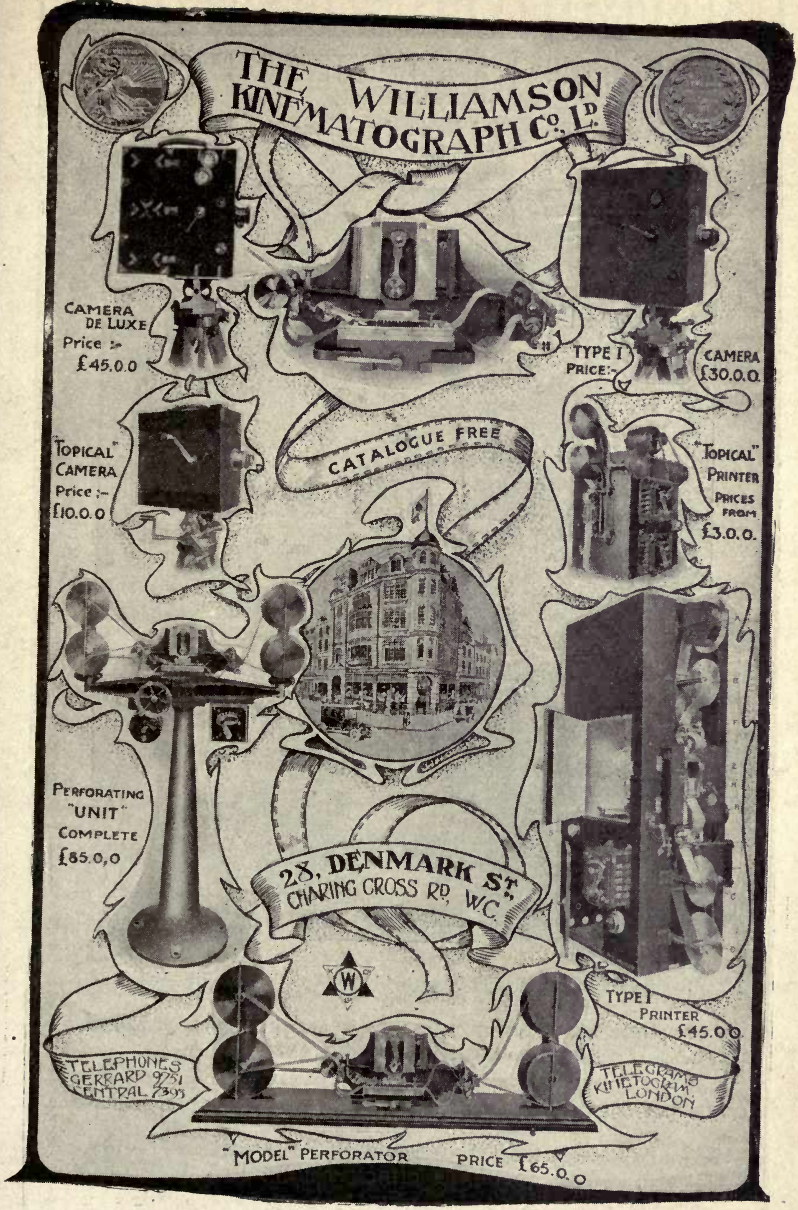
(24) Colour cinematography. (See Chap. VII.)

1898: 21649. **1899:** 6202, 17514, 23863. **1900:** 7035, 10000, 13883. **1902:** 249, 13468. **1904:** 7179. **1905:** 9465, 16104, 20600. **1906:** 20834, 25908, 26671. **1907:** 15726. **1908:** 453, 7514, 11791, 17309, 18750. **1909:** 1154, 5945, 9912, 10611, 16313, 18340, 27675. **1910:** 1717, 5025, 8761, 10892, 17872, 24779, 25869, 26927, 27207. **1911:** 1642, 6279, 9532, 12891, 15775, 18352, 20251, 21261, 23221, 23386, 23497, 23499, 23551, 23645, 24645, 24646, 24809, 26786, 27389, 28081. **1912:** 1489, 1900, 2218, 3034, 3220, 4045, 4774, 7477, 7756, 8207, 8626, 9313, 9324, 10150, 10639, 12229, 13510, 14133, 14340, 15027, 15478, 17385, 18098, 18431, 20555, 20556, 21271, 21623, 23289, 24159, 24161, 24534, 24948, 25084, 25142, 26292, 26827, 26828, 26976, 27207, 27708, 28365, 30108. **1913:** 1607, 2538, 2786, 2787, 3509, 5440, 6061, 6565, 6894, 6903, 7368, 8062, 8063, 8144, 9610, 11496, 11873, 12577, 14142, 15098, 16201, 16353, 16354, 17023, 19175, 20928, 22796, 22965, 27796. **1914:** 636.

(25) Living and speaking pictures and synchronizing (See Chap. VIII.)

1892: 15709. **1896:** 21382. **1898:** 13143, 21371. **1899:** 9200, 12036. **1900:** 6138, 13421, 21495. **1901:** 14479, 18015, 18426. **1902:** 8359, 26187. **1903:** 1093, 12612, 14427, 22563, 22564, 22566. **1904:** 7337, 7345, 7346, 15708. **1905:** 413, 26440, 26522. **1906:** 2157, 18057, 22888. **1907:** 206, 4429, 9391, 12969, 19713. **1908:** 327, 4145, 6194, 8496, 8865, 9370, 9371, 9372, 9445, 10396, 11333, 15140, 16611, 16728, 22415, 23153,

23276, 27717, 27766. **1909:** 453, 4899, 7426, 8838, 9419, 15981, 16941, 21675. **1910:** 3512, 7831, 21817, 24563, 29185. **1911:** 5840, 6390, 9622, 10158, 12732, 14072, 22458, 23620, 24091, 27911. **1912:** 2239, 3384, 4185, 4918, 7789, 10526, 13701, 14880, 15166, 18072, 19593, 21195, 29746. **1913:** 810, 1036, 1278, 4290 6727, 8694, 10519, 16941, 16942, 19764.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APPENDIX II

BIBLIOGRAPHY

THE present bibliography is divided into three parts.

A. The annotated bibliography which appeared in the first edition of the present work, and which extends up to 1898.

B. A further list of works of reference from 1898, wholly or mainly devoted to the subject.

C. A list of British and foreign magazines and periodicals wholly or mainly devoted to the subject.

The bibliography does not extend to works of reference or periodicals which from time to time have articles or supplements relating to cinematography, such, for example, as photographic works and periodicals. To have included such would necessitate a bibliography of works and periodicals devoted to photography, mechanics, electricity and electrical engineering, mechanics, theatrical subjects, and other auxiliary arts and sciences which are utilized in the science and art of cinematography.

A.—ANNOTATED BIBLIOGRAPHY TO 1898.

NOTE.—Roman figures indicate the number of the volume, Arabic figures the page. Figures in round brackets indicate a series. Author's notes, etc., are placed in square brackets. Only a limited number of articles are here noticed; reprints, translations, and purely trade notices are excluded.

1825. ROGET. Explanation of an optical deception in the appearance of the spokes of a wheel seen through

vertical apertures. [Spokes appear curved,—anorthoscopic phenomena.] Phil. Trans. 131.

1827. The Thaumatrope. [Editorial? by Brewster, see p. 5. Invention attributed to Dr. Paris.] Edinb. Jl. iv. 87.

1828. Plateau. Sur les apparences que présentent deux lignes qui tournent autour d'un point avec un mouvement angulaire uniforme. [Wheel phenomena.] Corresp. math. de Quetelet, iv. 373.

1829. Le Francois. Courbes d'intersection apparente de deux lignes qui tournent avec rapidité autour de deux points fixés. Ibid. v. 120, 379.

—— Plateau. Lettre relative à différentes expériences d'optique. [Wheel phenomena.] Ibid. vi. 121.

1831. Aimé. Phénomènes qui arrivent quand on met deux roues en mouvement l'une devant l'autre. Bull. de Férussac, xv. 103-107.

—— Faraday. On a peculiar class of optical deceptions. [Wheel phenomena; very interesting paper.] Jl. R. Inst. [n.s.], i. 205.

—— Plateau. Lettre sur une illusion d'optique, [Wheel phenomena.] Ann. de chimie et de phys. (2), xlviii. 281.

1833. Plateau. Sur un nouveau genre d'illusion d'optique. [Phenakistoscope.] Corresp. Obs. de Bruxelles, vii. 365.

—— Plateau. Des illusions sur lesquelles se fonde le petit appareil appelé récemment Phénakistiscope. [English name quoted as Fantascope.] Ann. de chimie et de phys. (2), liii. 304.

1834. Horner. On the properties of the Dædaleum, a new instrument of optical illusion. [See p. 22. Paper also contains full discussion of theory of distortion caused by moving slots.] Phil. Mag. (3), iv. 36.

—— Stampfer. Ueber die optischen Täuschungs-Phänomene welche durch die stroboskopischen Scheiben

(optischen Zauberscheiben) hervorgebracht werden. [Description of Stroboscope; suggestion of band.] K.K. polytech. Institut, Wien. Jahrbücher, xviii. 237.

1834. Stroboskopische Scheiben, Phänakistiskop, Phantasmaskop. Pogg. Annalen, xxxii. 636.

1835. SNELL. Description of an instrument for exhibiting a certain optical deception. [Phenakistoscope and wheel distortions. Stroboscope called Phantascope or Kaleidorama.] Sill. Jl. (1), xxvii. 310.

1836. PLATEAU. Notice sur l'anorthoscope. Bull. Acad. Bruxelles (1), iii. 7.

1846. MÜLLER. Anwendung der stroboskopischen Scheibe zur Versinnlichung der Grundgesetze der Wellen-Lehre. Pogg. Ann. lxvii. 271.

—— PLATEAU. Sur de nouvelles applications curieuses de la persistence des impressions de la rétine. [Illusive motion from modified anorthoscope.] Bull. Acad. Bruxelles (1), xvi. pt. i. 424, 588; pt. ii. 30, 254.

1850. TYNDALL. Phenomena of water-jet. [Momentary illumination by electric spark.] Phil. Mag. (4), i. 105.

1852. MOIGNO. Stéréo-fantascope ou Bioscope de M. J. Duboscq. [Combination of ordinary phenakistoscope with stereoscopic eyepieces.] Cosmos, i. 703.

—— PLATEAU. Sur le passage de Lucrèce où l'on a vu une description du fantoscope. Ibid. i. 307.

1853. POPPE. Das verbesserte Interferenzoscop [for exhibiting wave-motion.] Pogg. Ann. lxxxviii. 229.

—— ROLLMANN. Ueber eine neue Anwendung der stroboskopischen Scheiben. [Discussion of relation between number of slots and images.] Ibid. lxxxix. 246.

—— UCHATIUS. Apparat zur Darstellung beweglicher Bilder an der Wand. Wiener Akad. Sitz.-Ber. x. 482.

1858. ALMEIDA. Nouvel appareil stéréoscopique. [Alternate vision, projection or inspection, by eclipse or use of coloured screens.] Comptes rendus, xlv ii. 61.

1861. SHAW. Description of a new optical instrument called the "Stereotrope." [Double cylinder zoëtrope working on its side.] Phil. Mag. (4) xxii. 537.

1864. BABBAGE. Passages from the life of a philosopher. [Thaumatrope invented by Herschel and Fitton.] London.

1865. CLAUDET. On moving photographic figures, illustrating some phenomena of vision connected with the combination of the stereoscope and phenakistoscope by means of photography. [Views on rotating drums, alternate vision.] Brit. Assn. Rept. 1865, pt. ii. 9.

—— LAING. Combination of Stereoscope and Phenakistoscope. [Called the Motoroscope.] Mech. Mag. (2), xiii. 190.

1867. CLAUDET. New fact relating to binocular vision. [Stereo-thaumatrope, see p. 7.] Phil. Mag. (4), xxxiii. 549.

—— TOPLER and RADAU. Stroboscope ou Vibroscope universel [used to render the regular cyclic motion of a body slower in appearance by intermittent illumination.] Les Mondes, xv. 206.

—— WEBER. Theorie des Anorthoscops und der anorthoscopischen Figuren. Zeit. Math. u. Physik. xii. 133.

1868. CARPENTER. On the Zoëtrope and its antecedents. Student, i. 427; ii. 24.

—— CARPENTER. The Anorthoscope. Ibid. ii. 110.

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